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Intelligent Measured Data. Smarter Retrofit. Better Outcomes.

A study of how innovation in property technology can deliver better outcomes in social housing.

Pilot Study Report: The Science Behind the Insights

LLOYDS

Important Information

This report was commissioned by Lloyds and has been prepared by The Good Economy Partnership Limited (The Good Economy, or TGE), an independent impact advisory firm.

The findings and opinions conveyed in the Pilot Study Report and these Appendices are based on:

- Data provided by Senze, the project's technology partner on the 121 properties included in the pilot sample
- Data provided by Bromford Flagship, the project's housing association, on the pilot sample properties and supplementary data on its wider portfolio
- A third-party verification of Senze's method, which was provided by Birmingham City University
- A report from Salford University research facility, funded by UK Research and Innovation, which compares Senze's heat loss measurement algorithm with the "gold standard" co-heating benchmark
- Two workshops with the project's partners including Lloyds as the commissioner of the report, Bromford Flagship as the housing association, Senze as the technology provider and Birmingham City University as the independent verifier of Senze's method
- Regular meetings with Senze, Bromford Flagship and Lloyds stakeholders
- A site visit to two properties included in the pilot sample
- Supplementary research conducted by TGE's project team

The information reviewed should not be considered as exhaustive and has been accepted in good faith as providing a faithful representation of the pilot study. We have taken steps to ensure we do not intentionally or unintentionally inflate potential positive results or underreport negative results within our analysis of the expected implications of using measured data to guide a retrofit programme. However, we acknowledge there are limitations in the quantity and quality of data available. We have identified and explained the effect of these limitations on the conclusions drawn and implications to the best of our ability.

The Good Economy cannot and does not guarantee the authenticity or reliability of the information it has relied upon. The Good Economy reserves the right to alter the conclusions and recommendations presented in the Pilot Study Report and the Appendices in light of further information that may become available.

The Good Economy accepts no duty of care, responsibility, or liability (whether in contract or tort including negligence or otherwise) to any person other than Lloyds for any loss, costs, claims or expenses howsoever arising from any use or reliance on this report.

Document Overview

The Good Economy (TGE) was commissioned by Lloyds to provide an independent view on the expected environmental, social and economic impacts resulting from its Data-Led Retrofit Pilot Project.

TGE's headline findings can be accessed within the Pilot Study Report **here**.

This document sets out the appendices to accompany that report, including additional detail across several areas including context, in-depth findings, challenges and limitations and more detailed, technical commentary around the expected outcomes and the methodologies used.

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Appendix 1: Retrofit in Social Housing – The Landscape

Industry Landscape

Current net zero and building decarbonisation context

The urgent need for climate action has placed the decarbonisation of buildings at the forefront of sustainability efforts. In the UK, buildings represent the second-largest source of greenhouse gas emissions[1], underscoring the critical role of the built environment in achieving net zero targets. Given the scale of emissions associated with construction, operation and demolition, a fundamental shift towards maximising the potential of existing buildings is essential. Approximately 18% of the UK's annual CO_2 emissions originate from existing homes which will still be in use by 2050. In fact, 80% of the homes that will exist in 2050 have already been constructed.[2] Retrofitting this existing housing offers a significant opportunity to reduce carbon emissions, enhance energy efficiency and improve living conditions for residents.

Progress has been made in improving the energy efficiency of homes across the UK, reflecting advancements in insulation, heating systems and other energy-saving measures.[3] However, to align with the Government's net zero commitments, the pace of retrofitting needs to accelerate considerably.

The Climate Change Committee's Seventh Carbon Budget, published in February 2025, estimates the net cost of the UK's transition to net zero, if the country is to remain aligned with its 1.5°C commitment.

Based on this budget, the Built Environment alone will require £373bn in additional capital expenditure for the period from 2025 to 2050. Of the additional expenditure required across all sectors, 65-90% is expected to be funded by the private sector.[4]

Retrofit Context

Retrofit approaches

Home retrofit is the practice of upgrading homes to increase their energy efficiency and to reduce their reliance on fossil fuels for heating.

There are different approaches that can be taken to achieve this, though they are often used in combination. The two main approaches to retrofit are:

1. A **fabric first** approach which involves improving a building's energy performance primarily through modifications to its physical fabric, including walls, roofs and floors. This is likely to include optimising insulation, reducing thermal bridging, improving airtightness and incorporating balanced ventilation systems.
2. A **clean energy** approach which involves incorporating renewable energy systems and advanced technologies to reduce emissions.

Scale of retrofitting needed within social housing and residential sectors

As part of a consultation on minimum energy efficiency standards (MEES), the UK Government is proposing a deadline for all social housing properties to achieve an Energy Performance Certificate (EPC) rating of C or above – according to post-reformed EPC metrics – by 2030.[5] This target aims both to cut household energy bills and to support national climate targets. It applies to 4 million social rented homes in England – accounting for around 16% of the country's households.[6]

For social housing, retrofit programmes must balance substantial carbon reductions with affordability and equity. Tackling fuel poverty remains critical, as improving energy efficiency can directly lower energy bills and improve residents' quality of life. In this way, retrofitting can drive progress towards net zero while also creating healthier, more resilient communities.

The social housing sector is already playing a leading role in efforts to decarbonise the UK's housing stock. By 2023, 72% of housing association stock was rated EPC C or better – up from just 45% in 2013.[7] This far outperforms other tenure types, with only 48% of privately rented homes and 49% of owner-occupied homes rated EPC C or better.

Nevertheless, the challenge remains significant. Around 1.2 million social homes owned by housing associations and local authorities are still below EPC C. Meeting this target will require accelerated retrofitting, major investment, innovative delivery models, and coordinated action across both the public and private sectors.

PAS 2035 compliance under retrofit funding

To meet the proposed target for all social housing to achieve EPC C or better by 2030, the Government has committed substantial funding to housing associations. Its flagship initiative is the Warm Homes: Social Housing Fund (WH:SHF) (see across for more details), which is allocating £3.8 billion over the period 2020-2030 to support decarbonisation in the sector.

All WH:SHF-funded retrofit measures must comply with PAS 2035, the British standard for domestic energy retrofit. Introduced in 2019 following the Each Home Counts Review, PAS 2035 sets out processes for managing retrofit projects and provides guidance on implementing energy efficiency measures. Since June 2021, compliance has been mandatory for all publicly funded retrofit programmes.

Under PAS 2035, the guidance states that a 'fabric first' approach should always be considered – landlords are expected to prioritise measures that reduce energy demand and therefore bills through measures such as wall, loft and underfloor insulation.[8] As a result, fabric improvements have dominated decarbonisation efforts in the housing sector to date.

However, there is growing recognition that overly focusing on fabric-first retrofit risks misallocation of resources while overlooking other key decarbonisation measures, particularly the transition away from fossil-fuel heating.[9] Research funded by the Centre for Research on Energy Demand Solutions, for example, shows that in many cases, no further fabric upgrades are required to enable heating decarbonisation.[10]

Improving the fabric of buildings to enhance thermal performance will continue to have an important role in the context of retrofit, however clean energy approaches must also be considered. Undertaking right-sized approaches based on the specific needs of individual properties, combining fabric improvements and/or low carbon heating systems, has the potential to produce improved outcomes. Assessing these potential outcomes is a key element of this pilot project.

EPC regime in context

First introduced in 2007, EPCs have been an important tool used for defining standards, raising awareness and setting targets in relation to energy efficiency. However, evidence increasingly shows that EPCs are often inaccurate and offer little correlation with a building's actual energy efficiency.[11] According to a recent Which? report, there is substantial evidence that the metrics and information in many EPCs may be misleading, and homeowners, tenants, landlords and policymakers could be making decisions based on inaccurate information.[12]

These concerns have led to the UK's independent advisor on climate change calling on the Government to reform the EPC system, stating it is "not fit for purpose".[13] And these calls have clearly been heard by Government – in December 2024, it released a consultation to reform the energy performance of buildings regime, with a decision expected in 2026.[14]

Among the proposed reforms are proposals to update EPC metrics, and to refine the requirements for EPCs. Within the Government's consultation, there is acknowledgement of the fact that EPC metrics could make greater use of measured energy consumption and other time-series data. This could include the type of real-time thermal performance data collected within this pilot project.

Funding Environment

Current state of funding

In the years leading up to 2050, housing associations already plan to invest £70bn (excluding grant funding) on the fabric, heating systems and components of their existing homes. However, the National Housing Federation (NHF) estimates that decarbonising all housing association homes will require at least an additional £36bn in investment, representing a 50% increase over existing plans.[15]

The Warm Homes: Social Housing Fund[a]

The Warm Homes: Social Housing Fund (WH:SHF) has been a key government grant programme supporting retrofit initiatives in the social housing sector. The fund was established in 2020 with the Government pledging to release £3.8bn over a 10-year period to improve the energy performance of social rented homes. Registered Providers of social housing (RPs) are eligible to apply for funding through WH:SHF. To be successful, RPs are required to demonstrate that they meet the Government's requirements. The RP is then required to provide match funding to finance the retrofit works, meaning the cost is split 50/50 between the RP and the Government.

The scale of the Warm Homes: Social Housing Fund shows a material investment from Government and signals that the retrofit of social housing stock is a key priority area.

The role of private capital in funding retrofit

Despite the Government's substantial commitments in this area, funding remains a major barrier to delivering retrofit at the scale and quality required. In 2020, 74% of housing associations identified financial constraints as the biggest challenge to retrofit.[16] This is largely driven by the fact that retrofit requires high upfront costs yet housing associations, particularly smaller organisations, can face challenges in accessing funding, whether through government-funded grants or the private sector.[17]

[a] Note that the Warm Homes: Social Housing Fund is the new name for what was previously known as the Social Housing Decarbonisation Fund. The name was changed in November 2024.

Most housing associations are not-for-profit, meaning they can't raise equity finance, leaving debt as the only private capital option. For a housing association that is already close to its gearing limit, every pound spent on retrofit is a pound that can't be spent on delivering new homes. Also, these costs cannot be recouped because the cost-savings generated through energy efficiency improvements accrue to residents rather than the housing association, as it is residents who pay the energy bills.

Given these challenges, there is a significant role for the private sector to play in financing the sector's transition to net zero, particularly if it can help to identify innovative solutions. Lloyds is already the largest lender to the UK social housing sector and has provided over £20 billion in finance to the sector since 2018 through commercial lending and deal facilitation, enabling more homes to be built.

The National Wealth Fund

This product is competitively priced and unsecured, so helps unlock investment that might otherwise be constrained by security or covenant limitations. Lloyds has committed to lend a minimum of £500m to finance the retrofit of social homes, partially guaranteed by the National Wealth Fund, and the funding can be applied to a wide range of eligible measures including low-carbon heating systems, insulation, ventilation, renewable energy installations and resilience upgrades. The use of intelligent measured data, accessed through technology from providers like Senze to inform these measures are also eligible for our green finance offering.

The ambition is to work with the sector to amplify the impact of grant funding, helping mobilise private capital at scale to accelerate progress towards the Government's net zero goals. The aim is that this also supports a Just Transition by lowering the costs for both housing associations and social housing tenants.

This is a great case study of how innovation and public-private collaboration can play a pivotal role in addressing one of the UK's most pressing climate and social challenges. We look forward to seeing how the pilot study is expanded in scope from here.

David Cleary
Managing Director, Housing,
Lloyds Corporate &
Institutional Banking

Challenges and Opportunities

Implementation challenges

Clearly, the scale of retrofitting needed in the UK is significant and will require substantial funding. Delivering on the Government's proposed targets under existing models is complex and faces several implementation challenges:

Cost barriers – JLL estimates an average cost of £35,000 per property to retrofit an existing home (note this relates to all housing, not just social housing).[18] Applied to the 1.2 million social homes below EPC C, this implies a funding requirement of around £42 billion.

Cost uncertainty – In addition to cost barriers, there is a level of cost uncertainty surrounding retrofit, which can make budgeting and planning difficult for housing associations and other large-scale landlords. The JLL paper referenced above has been widely cited and is broadly aligned with data we have seen from Bromford (prior to its merger with Flagship) on its retrofit spending to date. However, there is a wide range of cost estimates out there. For example, a recent government paper estimated that it will cost housing associations an average of £5,752 per home to improve the EPC rating to band C.[19] In addition, in 2022, the NHF and Local Government Association (LGA) classed 5% of social housing homes as 'hard to treat', estimating that they would cost more than £20,000 to decarbonise. This uncertainty complicates planning and investment decisions. Wider adoption of technology-led approaches could help improve cost certainty.

Skills shortages – Delivery capacity is constrained by labour and supply chain gaps. In 2022, Nesta identified only 3,000 trained heat pump engineers in Britain, compared to at least 27,000 needed by 2028 to meet Government targets.[20]

Resident resistance – Existing research demonstrates that it is common for retrofit projects to encounter resistance from residents.[21] Commonly cited reasons include uncertainty or concerns relating to the technical aspects, perceptions that the process is disruptive, or worries over potential changes to the aesthetics of the property. This is especially important in the context of social housing, where tenants are rarely involved in the decision-making process. The emerging concept of 'retrofit justice', focusing on how retrofits should occur equitably and fairly, has become increasingly important to ensure projects positively impact wellbeing and do not exacerbate existing inequalities.[22]

Unintended consequences – To date, retrofit approaches have tended to focus on energy efficiency measures for climate mitigation, overlooking the need for adaptation. Evidence shows that this can inadvertently create issues such as increasing the risk of over-heating, leading to worse living conditions for residents.[23]

The potential opportunity through technology-enabled approaches

Given the challenges, digital technology could play a critical role in scaling retrofit by improving understanding of building energy use, thermal performance, and the targeting of interventions.[24] Its value lies in enabling programmes to be scoped, designed, and implemented based on measured property-level data rather than modelled data derived from EPC ratings.

In the UK, EPCs are calculated using the Standard Assessment Procedure (SAP), which estimates a building's energy use based on physical characteristics (such as insulation levels and heating system efficiency) and standardised assumptions about occupancy. However, research shows that SAP modelling often overestimates actual energy consumption compared with measured data.[25] This can result in inaccurate targeting, inefficient use of funds, and poor outcomes for residents.

Appendix 2: Theory of Change

A Theory of Change is a conceptual framework that maps out how a project is expected to contribute to specific outcomes and impacts.

We have developed a Theory of Change to articulate our understanding of the impact the project is expected to deliver and demonstrate the thinking underpinning this logic. It also provides the foundation for the impact assessment plan outlined on p.35. Therefore, it could provide a framework to enable housing associations to assess actual impact delivered once works have been carried out, if adopting a measured data-led approach to retrofit.

The insight provided by a measured approach is only beneficial if acted on effectively. The value of a Theory of Change lies in the fact that it clearly outlines what activities need to happen informed by that insight, and which organisations need to undertake them, for the theory to play out in practice.

Our Theory of Change is based on research and learnings during the pilot and has been informed by all relevant project partners including residents. This included mapping out:

- What are the challenges to which this pilot project is seeking to explore a potential solution?
- What are the activities, outputs and outcomes through which change is expected to occur?
- What are the impact risks that need to be managed throughout the process?
- What is the basis for the Theory of Change?
- What are the assumptions that need to hold true for the theory to play out in practice?

What are the challenges to which this pilot project is seeking to explore a potential solution?

Environmental

Need for retrofit:

- Buildings are the second-largest source of GHG emissions in the UK, therefore retrofit is key to achieve wider net zero goals.[26]
- The Government is proposing a deadline for all social housing to meet EPC C or better – according to reformed EPC metrices – by 2030 (currently 28% of housing association stock is below this standard) and net zero emissions by 2050.[27]
- There is a risk of stranded assets (i.e. properties that become economically unviable due to irrecoverable expenditure) and a reduction in the stock of much-needed social housing if poor-performing assets cannot be occupied or need to be sold off by housing associations.[28]

Social

Housing and health:

- It is estimated that 6.1 million households in the UK are in fuel poverty.[29]
- Poor quality housing leads to preventable health conditions and costs the NHS over £1bn in treatment bills.[30]

Economic

Funding challenges:

- The Government's WH:SHF is providing valuable grant funding to complete retrofit works, but the £3.8bn total, which was originally committed by the Conservative government in 2019 to be allocated over 10 years, covers only a small proportion of the total cost. Private finance is needed to cover the remainder.[31]
- Housing associations plan to invest £70bn upgrading existing homes to 2050. The NHF estimates an additional £36bn is needed for housing associations to achieve full decarbonisation.[32]
- 74% of housing associations identify funding constraints as the biggest challenge to retrofit.[33] As organisations, housing associations face significant economic challenges due to the considerable competing demands on their finite funding resources, including developing new homes, health and safety and remediation works, energy efficiency upgrade requirements, and more.

Cross-cutting

Implementation challenges:

Evidence shows that EPCs are often inaccurate and offer little correlation with a building's actual thermal performance and energy use.[34] This results in several significant risks:

- That retrofit based purely on EPCs does not accurately measure or target energy efficiency and heating solutions to deliver net zero homes.[35]
- Of contributing to 'sick building syndrome' if homes are over-insulated without sufficient ventilation, trapping moisture and pollutants, creating an environment conducive to humidity problems and poor air quality.[36]
- That public and private money is being used inefficiently (in a sector already grappling with significant funding challenges).

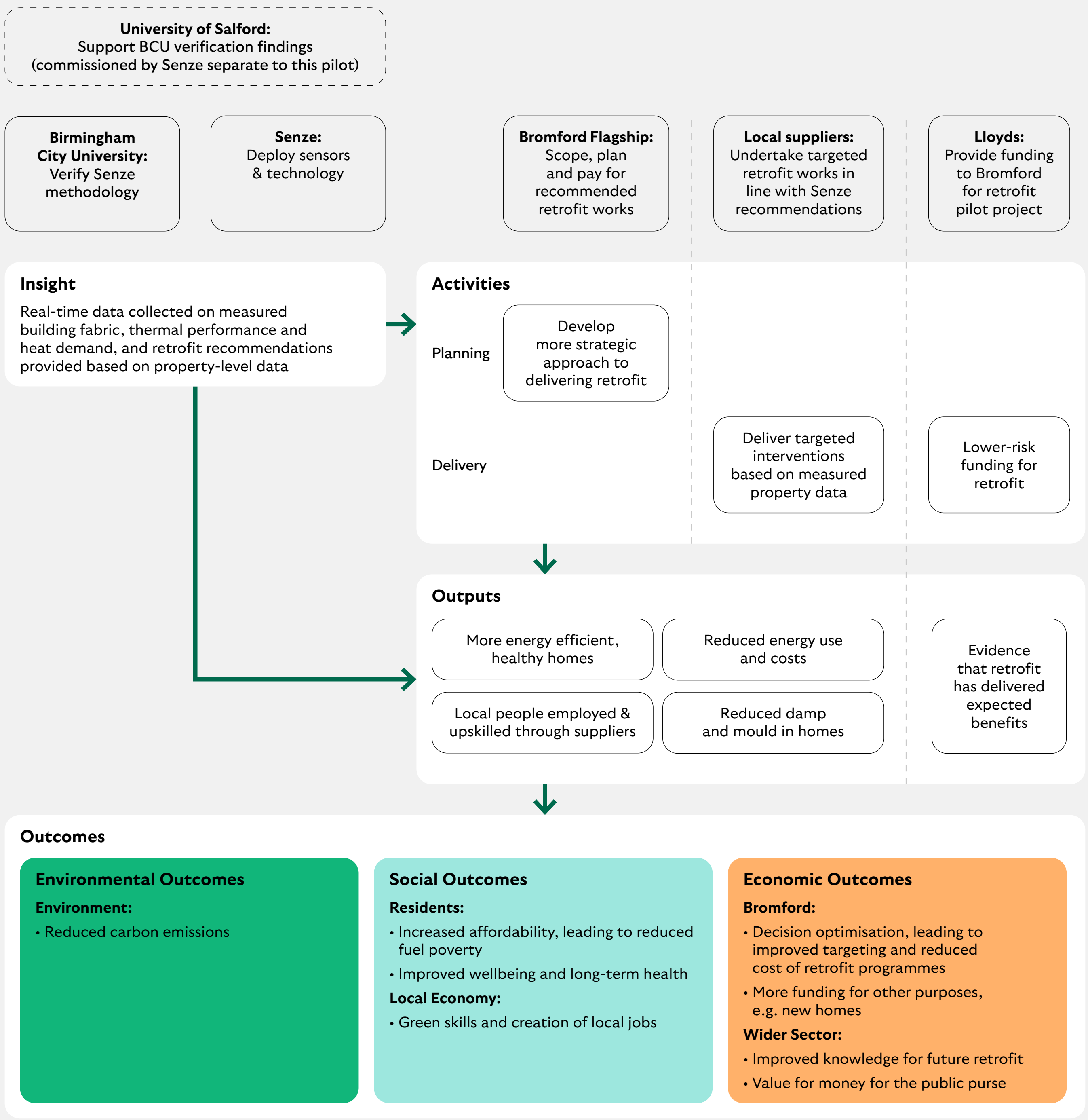
Barriers to adoption of technology-enabled solutions:

There are various barriers to widespread adoption of technology-enabled solutions in the social housing sector (such as that provided by Senze). These include:

- Perceptions of cost, and natural resistance of housing associations due to the need for long-term planning and long-term payback on initial outlay.[37]
- Resident apprehension towards installing technology in homes, and resistance to perceived disruption.[38]
- Cost and length of time required for monitoring, including requirement for a large amount of monitoring equipment (e.g. sensors), particularly if deploying across a large portfolio.

What are the activities, outputs and outcomes through which change is expected to occur?

Figure 1: Theory of Change Model



What are the impact risks to be managed throughout the process?

Operational:

- **Quality oversight** – Ensure appropriate quality oversight of the retrofit process to ensure the execution of the works is carried out in line with recognised quality standards.
- **Embodied carbon** – Manage embodied carbon emissions associated with undertaking retrofit works.
- **Employment standards** – Ensure suitable employment standards are followed by installers and retrofit firms.
- **Liability risk** – Housing associations to promptly mitigate potential negative outcomes for residents based on improved data.

Customer-related:

- **Resident disruption** – Disruption to residents is minimised during installation of sensors and undertaking of any required retrofit works.
- **Resident involvement** – Some evidence has shown that disenfranchisement and misrecognition of issues can lead to social housing residents becoming disengaged from the process. Therefore, there is a need to ensure that residents are involved and made aware of the decision-making process in relation to required works.
- **Data collection concerns** – Ensure resident concerns around data collection and having the sensors in their homes are heard and understood where possible to minimise non-participation or detrimental wellbeing impacts.

Basis and assumptions underpinning the Theory of Change

The content below outlines the basis and assumptions underpinning the theory of change illustrated in Figure 1: Theory of Change Model. This refers to:

- **Basis** – the resources we have drawn on, which evidence why we think the identified outcomes could result from the activities carried out through this retrofit project.
- **Assumptions** – the assumptions that would need to hold true for the causal logic outlined in the theory of change to play out in practice.

Basis

Outcome Area	Outcome	Reference(s)
Environmental Outcomes	Reduced carbon emissions	Energy Transitions Commission, 2025. **Achieving Zero-Carbon Buildings.**
Social Outcomes	Increased affordability, leading to reduced fuel poverty	RIBA, 2020. **Greener Homes: Decarbonising the housing stock.** NEF, 2025. **A blueprint for warmer homes: how to deliver a retrofit revolution.**
	Improved wellbeing and long-term health	Maidment et al, 2014. **The impact of household energy efficiency measures on health: A meta-analysis.** Ige et al, 2018. **The relationship between buildings and health: a systematic review.**
	Green skills and creation of local jobs	IPPR, 2022. **Train local, work local, stay local: Retrofit, Growth and Levelling Up.**
Economic Outcomes	Decision optimisation, leading to improved targeting and reduced cost of retrofit programmes	This pilot project – demonstrating potential for housing associations to more effectively plan, scope and target retrofit programmes based on measured data, with potential economic implications relating to financial investment required from housing associations, industry knowledge on viable route to retrofit, and publicly-funded retrofit programmes.
	More funding for other purposes, e.g. new homes	
	Improved knowledge for future retrofit	
	Value for money for the public purse	

Assumptions

- **Occupier behaviour** – Assumption that residents manage their homes appropriately in order to realise energy savings and social outcomes resulting from improved efficiencies of the building (evidence shows this is not always the case).
- **Sensor and Live Thermal Measurement Algorithm (LTMA) effectiveness** – Assumption that the sensors are effective in collecting accurate data, and that the LTMA is effective to accurately measure a building's thermal performance (note this assumption has been tested through Birmingham City University's verification process of Senze's methodology).
- **Sector readiness** – Assumption that housing associations and residents are willing and ready to utilise technology-enabled approaches within retrofit planning and delivery.
- **Up-front funding available for sensors/data** – Assumption that there is funding available to cover the initial costs required to install sensors and deploy technology.
- **EPC policy environment** – Assumption that EPCs remain as a key metric guiding decisions in terms of retrofit priorities and policies.

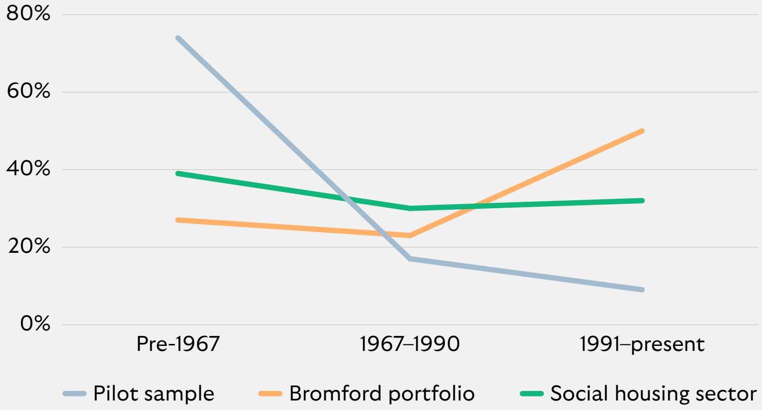
Appendix 3: Pilot Sample – Portfolio Composition

The pilot sample consists of 121 properties, out of a total sample of around 40,000 homes across Bromford's portfolio (0.30%), and a sample of 80,000 across Bromford Flagship's portfolio following their merger (0.15%). See below for further details on the pilot sample breakdown in terms of age profile, building type, EPC rating and retrofit stage, including commentary on and comparison against the Bromford portfolio and the wider social housing sector.[39]

Category	Sample count	Sample percentage	Bromford portfolio	Social housing sector
Age profile				
Pre-1967	90	74%	27%	c.39%
1967 - 1990	20	17%	23%	c.30%
1991 - present	11	9%	50%	32%
Building type				
Detached/Semi-detached	61	50%	28%	17%
Terraced	24	20%	28%	28%
Flat	19	16%	32%	43%
Bungalow	16	13%	12%	12%
Maisonette	1	1%	–	N/A
EPC Breakdown				
A	0	0%	1%	<1%
B	7	6%	19%	15%
C	34	28%	71%	57%
D	50	41%	9%	22%
E	28	23%	<1%	2%
F	2	2%	<1%	<1%
Not known	0	0%	<1%	4%
Retrofit stage				
Pre-retrofit	65	54%	-	-
Mid-retrofit	40	33%	-	-
Post-retrofit	16	13%	-	-

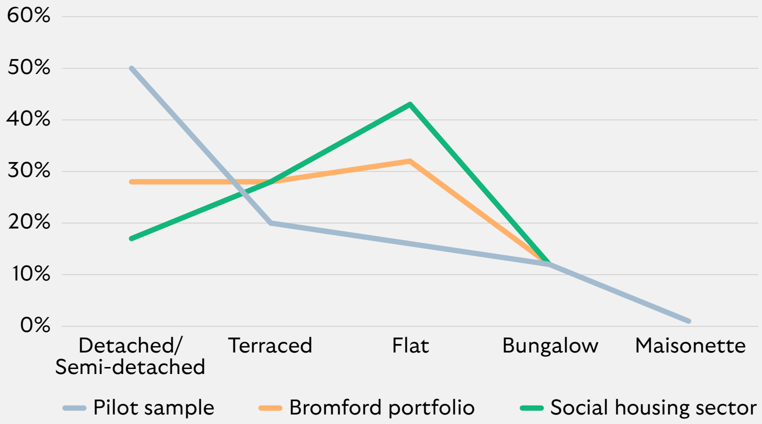
Bromford's portfolio (rather than Bromford Flagship) has been used for the basis for this assessment of the representativeness of the pilot sample. This is because representatives from Bromford (rather than Flagship) were our primary contacts during the pilot project, and this is the portion of the portfolio on which we received comprehensive portfolio data.

Figure 2: Age profile



The pilot sample is substantially weighted towards older properties vs the wider Bromford portfolio and the social housing sector. This is a result of the fact that the pilot sample is intentionally weighted towards older properties that are either earmarked for retrofit, or have been, or are already in the process of undergoing retrofit.

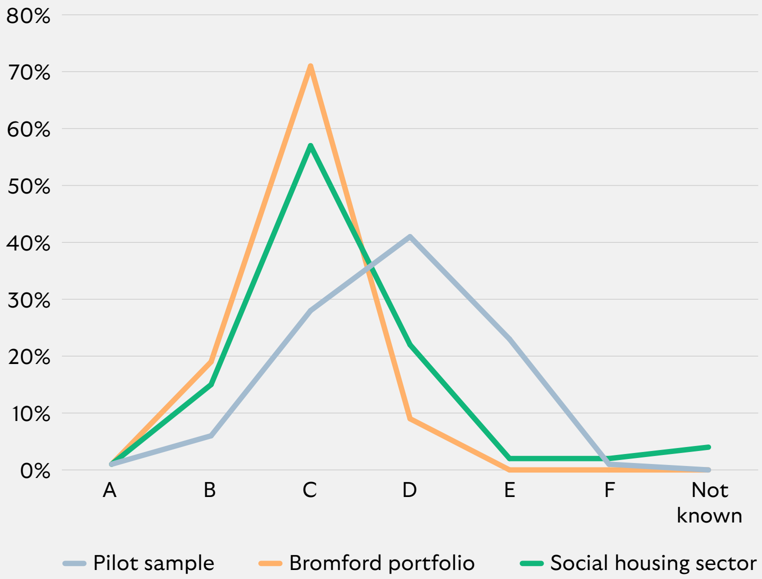
Figure 3: Building type



The pilot sample is substantially weighted towards detached and semi-detached properties, and with a lower proportion of flats vs the wider Bromford portfolio and the social housing sector.

This was due to challenges encountered accessing flats to be included in the pilot sample.

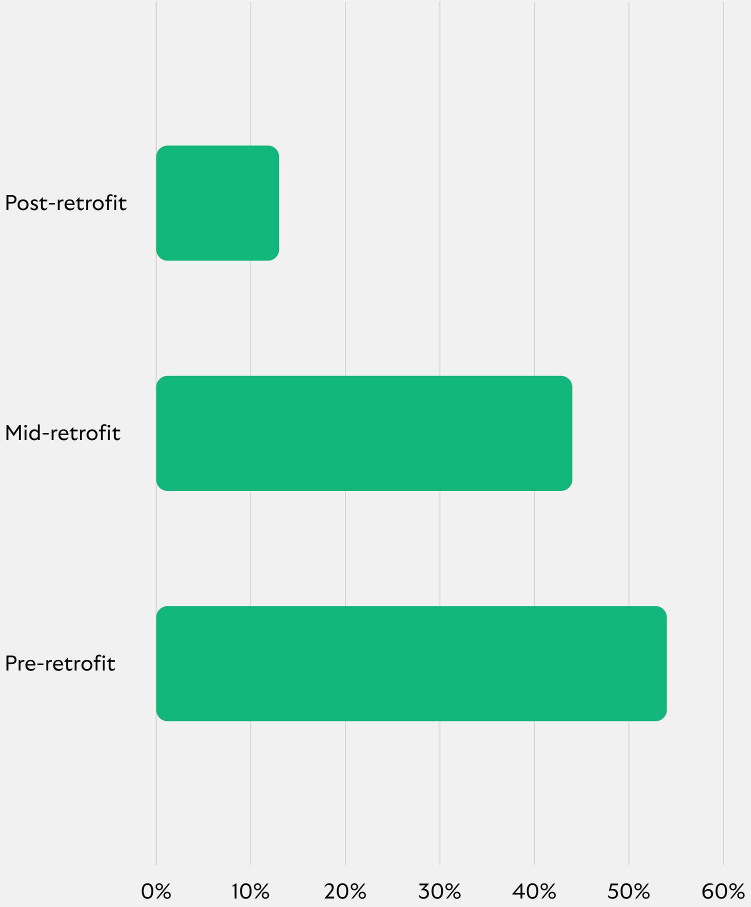
Figure 4: EPC Breakdown



The pilot sample is more evenly distributed across EPC ratings vs the Bromford portfolio and the social housing sector, with a greater proportion of properties rated EPC D, E and F included in the pilot sample.

Again, this is a result of the fact that the pilot sample is intentionally weighted towards properties with lower EPC ratings that are either earmarked for retrofit, or have been, or are already in the process of undergoing retrofit utilising government grant funding.

Figure 5: Sample portfolio – Retrofit stage



The pilot sample includes a range of properties across the retrofit lifecycle, including:

- **Pre-retrofit** – properties earmarked for retrofit, that have had no works undertaken yet.
- **Mid-retrofit** – properties that have had some retrofit interventions carried out, but not the full programme of planned works.
- **Post-retrofit** – properties that have already undergone a full programme of retrofit works, funded by Bromford or Flagship and SHDF funding.

This typology was included to enable a comparison against the counterfactual, i.e. properties that have already undergone or were planned to undergo retrofit based on a traditional EPC-led approach, utilising government grant funding.

Clearly, this data shows that the pilot sample is a small and deliberately skewed sample of a much larger portfolio. This should therefore be borne in mind when assessing results and considering the potential implications.

For this pilot project, we have not attempted to aggregate the results to a wider portfolio (e.g. Bromford Flagship's wider portfolio), and instead have separated the analysis out according to the four different property groups identified, based on their measured and modelled EPC rating.

Appendix 4: A Measured Approach to Retrofit

Senze's approach utilises room-by-room smart sensors and smart meters to continuously monitor and record temperature, humidity, pressure and energy consumption data. These sensors link into Senze's software platform which combine digital twin models to monitor building performance and assess energy use.

The Senze process works as follows:

1. **Pre-assessment** – the Senze tool analyses and scrapes publicly available property data to build out an initial understanding of a portfolio and uses some of the information to avoid duplication of input and to streamline the on-site installation time. It also analyses the portfolio to understand where to prioritise sensor installation.
2. **Digital twin capture** – Senze surveyors utilise LiDAR (Light Detection and Ranging) technology to scan all rooms in a property. This captures structural dimensions such as volumes, surface areas, materials and thicknesses and digitises them into a detailed 3D 'digital twin'.[b]
3. **Sensor and meter installation** – sensors are installed throughout each property to monitor thermal conditions in real-time. With the appropriate property-owner or tenant consent, Senze can also link into the home's gas and electric meters to pull live consumption data directly from the grid.
4. **Live thermal and energy analysis** – once the sensors have been installed, Senze's platform takes continuous readings to calculate live thermal measurement analysis, charting the property's heating profiles, thermal performance and energy consumption on a room-by-room basis.[c]
5. **Recommendation and optimisation** – based on the data collected, Senze can simulate retrofit options, assessing their relative cost, expected energy savings and carbon impact. This aims to make use of room-level measurements to identify interventions that will be most effective and have the greatest impact, targeting areas of the property where improvements are most needed.

Senze's technology service is carried out at a typical cost of £1,500 per property.

Using measured data to scope a retrofit programme

This pilot offers an alternative approach to typical retrofit programmes which are generally based on EPC-modelled scenarios. Whereas a more traditional approach would use EPCs to identify which properties require improvement works (i.e. those rated EPC D or worse), this pilot project makes use of real-time property-level data to understand which properties are at risk of fuel poverty, heat loss (or overheating) and damp and mould.

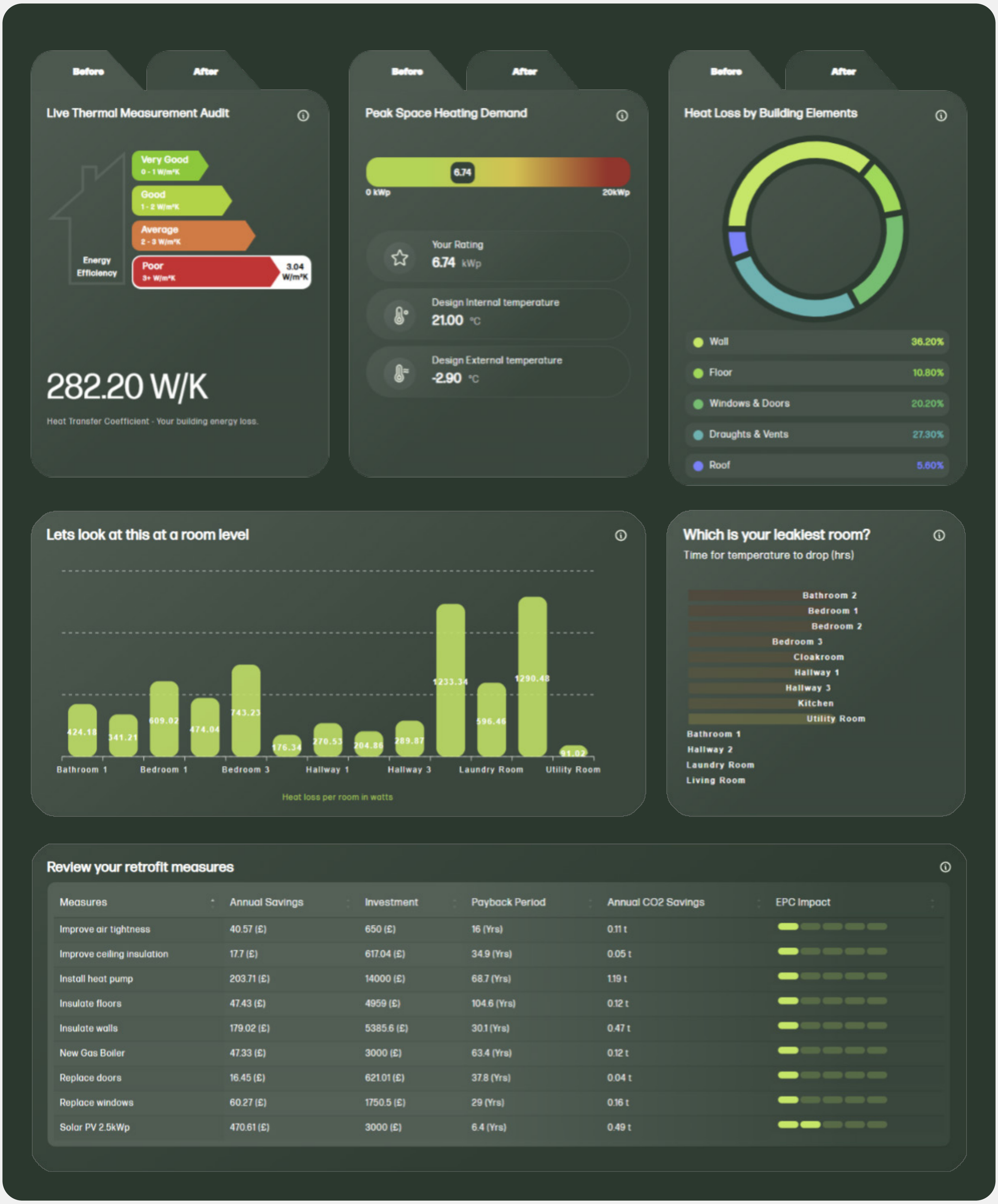
Also, where an EPC-modelled approach would estimate the required works to the building based on the information provided by its EPC certificate, this platform makes use of that real-time property-level data to suggest the targeted works which will be most effective to upgrade the performance of each specific property, on a granular, room-by-room basis. This incorporates considerations such as financial savings, investment amount (and payback period), CO_2 savings, and EPC impact.

[b] A **digital twin** is a virtual model of an object, a system, or a process. It is connected to its real-world counterpart by a 2-way flow of right-time data, meaning it mimics it in all aspects (definition from the **Department for Business and Trade**).

[c] Definitions as follows:

- '**Heating profiles**' refers to a property's peak heat load, i.e. the maximum heating required to maintain the desired indoor temperature, during the coldest periods.
- '**Thermal performance**' refers to a property's Heat Transfer Coefficient, i.e. the rate at which a property loses heat through its external envelope
- '**Energy consumption**' refers to the energy consumed within a property during the measurement window.

Figure 6: Example Senze data dashboard



Measures	Annual Savings	Investment	Payback Period	Annual CO2 Savings	EPC Impact
Improve air tightness	40.57 (£)	650 (£)	16 (Yrs)	0.11 t	
Improve ceiling insulation	17.7 (£)	617.04 (£)	34.9 (Yrs)	0.05 t	
Install heat pump	203.71 (£)	14000 (£)	68.7 (Yrs)	1.19 t	
Insulate floors	47.43 (£)	4959 (£)	104.6 (Yrs)	0.12 t	
Insulate walls	179.02 (£)	5385.6 (£)	30.1 (Yrs)	0.47 t	
New Gas Boiler	47.33 (£)	3000 (£)	63.4 (Yrs)	0.12 t	
Replace doors	16.45 (£)	621.01 (£)	37.8 (Yrs)	0.04 t	
Replace windows	60.27 (£)	1750.5 (£)	29 (Yrs)	0.16 t	
Solar PV 2.5kWp	470.61 (£)	3000 (£)	6.4 (Yrs)	0.49 t	

Appendix 5: Birmingham City University Verification Findings

1. Scope of review

Birmingham City University Centre for Future Homes was commissioned to undertake a verification of the Senze approach and outputs. This analysis considered the objectives, operation, and outputs of the Senze system. It was limited by time and data availability but also commercial sensitivities relating to the Senze system. Senze provided documents, energy and sensory data and were interviewed in detail. Two properties were analysed to ascertain the viability of the Heat Transfer Coefficient (HTC) estimation and a further two were analysed to assess the economic evaluation of refurbishment options. Another four properties at different retrofit stages were analysed to ascertain the impact on indoor air quality.

2. What is Senze?

a. What it does

The Senze system has been designed for housing asset managers to access energy information about their portfolio in order to make decisions about energy retrofits and to determine the most urgent properties for retrofit. The data is partly collected and partly measured remotely. The system can also show the benefits of retrofit by comparing before and after installation, to give asset owners better decisions on refurbishment that meet regulations and provide value for money.

b. How it works

The Senze system is based around a central asset database into which individual property data is stored. This database sends data for individual properties to their HEAT energy model which can calculate energy use theoretically from geometry and surface construction materials data. A similar LTMA model also takes live temperature and energy supply data and can calculate real time values of energy use, property performance and heat loss from each room. This measured data is used to derive a real HTC value which is then used to modify the model parameters so that it can more accurately assess retrofit options. “HTC” Heat Transfer Coefficient is a measure in Watts per Kelvin (W/K) of a building’s overall thermal performance. A lower HTC indicates less heat loss and better thermal performance. This live modification, based around trigger events, is a type of learning so that any predictive estimates from the model are more accurate. Once this HTC figure is found then carbon emissions arising from energy use, benefits of retrofit options and post retrofit EPCs can be calculated.

c. What is unique about it?

The Senze system has a number of important features some of which are unique: (i) It can provide results from very grainy energy data. (ii) It uses a multi-room assessment from temperature sensors in each room giving a much finer analysis of heat loss. (iii) More accurate room geometry is collected using 3D Room scanning with a phone adding to the construction details. (iv) The temperature decay in each room is monitored and used to upgrade the heat loss results for each room. (v) The system collects data until uncertainty levels in the estimates are reduced driven by trigger events. (vi) This learning produces a greater level of accuracy.

The dashboard of multiple assets provides access to the full data and ongoing monitoring including comfort and health. It also provides estimates of retrofit benefits and costs, thus enabling an economic analysis of a portfolio.

d. What are the assumptions?

The Senze system has been designed to provide access to real live data so that better decisions can be made against SAP calculation. There are a number of assumptions which limit the value of this: (i) EPC currently does not accept real performance data. (ii) The calculation of heat energy from gas and electricity readings is very speculative with little awareness of the real performance of heating systems. (ii) Occupancy can upset in-use Heat Loss Measurement calculations but the Senze system improves on this by collecting data over more days until sufficient event triggers are found. (iii) Properties with different ages and constructions of additions have particular difficulties although the Senze system partially deals with this by considering different rooms.

3. HTC estimate

a. Study based on Salford data

The University of Salford (“Salford”) supplied Senze with temperature and energy input data from a full size, unoccupied test house built in their climate-controlled chamber. Salford had measured the thermal performance of this house using the very robust co-heating method. Senze used their system with the temperature and energy data supplied and determined an HTC value which they found to be within 1.3% of the value determined by the Salford co-heating test. This is an extremely good result with the reservation that the house had no complications of occupation and the heating energy use was a straightforward calculation.

b. Study based on reverse engineering IES simulation

Birmingham City University conducted a simulation exercise to check the Senze HTC calculation using IES software. This involved taking house geometry and simulating a month's operation using real weather data and internal temperature profiles. The U values and ventilation were modified in order to achieve the monitored daily energy use over the month. Senze HTC results were within range of expected values, accounting for assumptions in simulation and confidence intervals. This similarity demonstrates the adequacy of Senze for calculations for assessing retrofit options and certainly better than RdSAP.[d]

4. Costing of refurbishment options

Having calculated the live HTC and proportioned to rooms, the Senze system can calculate the benefits of various retrofit measures using their HEAT algorithm. In addition, by using cost/m^2 for the measures then the cost of the measure can be estimated and a cost benefit analysis undertaken. The costs were obtained from independent cost data and Bromford Flagship's actual costs (see Appendix 10, Cost Comparison Methodology) to ensure results were robust. The results showed good order of magnitude benefits and costs. However, installation costs can vary significantly because of complexities of individual properties, whether a number of properties are being retrofitted the same option, and what the market condition for the work is. The Senze system can be used to monitor the properties post-retrofit and both the performance and costs can be updated with better data as programmes are rolled out.

5. Indoor air quality assessment

The occupation of houses produces many detrimental products which can cause health problems for occupants. It is important for houses to deal with these mainly through controlled ventilation and low-cost heating. It can be the case that retrofit can create unintended consequences which require more actions to avoid poor indoor air quality. Senze can monitor indoor air quality and show the readings in the dashboard, allowing to observe the occupation problems of the house and the way that the installed ventilation and heating systems are working. Two pre-retrofit and two post-retrofit properties with monitoring were reviewed by BCU. Findings showed that humidity was between safe levels across all dwellings. Pre-retrofitted dwellings showed high range of indoor temperatures indicating poor energy performance and high levels of heat loss. In contrast, retrofitted homes showed better indoor air quality and more stable indoor temperatures, denoting better ventilation systems and insulation as well as demonstrating that the systems installed as part of the retrofit works are adequate for the occupants' lifestyle.

[d] Reduced data SAP (RdSAP) was introduced in 2005 as a simpler and lower cost method for assessing existing dwellings. An RdSAP assessment will use a set of assumptions about the dwelling, reducing the volume of data an energy assessor must collect (definition from **www.gov.uk**)

Appendix 6: Key Findings

Outlined below are the key findings based on the data collected by the installed property sensors across the sample portfolio of 121 properties. This includes findings related to the internal conditions of the properties, their energy use and carbon impact, and their thermal performance. This data was provided to TGE by Senze, with TGE then undertaking analysis based on the data provided.

The average measurement period for data collection was 21.8 days. Sensors were installed between January and July 2025.

It should be noted that it should be seen as a strength of Senze's Live Thermal Measurement Algorithm (LTMA) that the thermal performance of a property can be estimated to a high degree of accuracy over a short measurement window and is minimally affected by occupancy patterns, seasonal variation, or resident behaviour (as noted in the findings of Birmingham City University's verification). However, the relatively short measurement window does have implications relating to the observed property conditions during the pilot, as explained on p.36.

Headline Overview Key Metrics

Area	Data Point	Description	Unit	Mean	Median	Min	Max
Property conditions	Property temperature	Measured internal property temperature.	°C	19.9	19.9	12.1	25.9
	Property humidity	Measured internal property humidity.	% relative humidity	53.2	53.4	37.1	68.4
Energy use and carbon impact	Estimated primary annual energy use	Estimated primary annual energy use calculated based on property conditions, usage and thermal performance.	kWh per m^2	128.7	124.7	24.2	297.7
	Estimated annual operational carbon emissions	Estimated annual carbon emissions calculated based on emission source and emission factor.	kg per m^2	24.8	24.3	5.1	54.5
Thermal performance	Heat transfer coefficient	The rate at which a building loses heat through its external envelope (walls, roofs, windows), measuring the rate of heat loss per degree of temperature difference between inside and out.	W/K	206.4	193.1	31.2	700.2
	Peak heat load	The maximum amount of heat a property requires to maintain a comfortable indoor temperature during the coldest conditions.	kWp	4.9	4.6	0.8	16.7
	Thermal performance gap	The difference between the modelled heat transfer coefficient based on the property's stated EPC rating, and the equivalent measure based on the data collected by installed sensors.	% difference	25%	12%	-70%	390%

Property conditions

In this pilot, the data has been treated differently for thermal performance and property conditions.

The **thermal performance** of the properties was assessed using measured data and Senze's LTMA, which estimates performance over a short measurement window and is unaffected by occupancy patterns, seasonal variation, or resident behaviour.

By contrast, **internal property conditions** (e.g. temperature, humidity) are directly influenced by occupancy, resident behaviour, and seasonal differences.

As no occupancy data was collected for this project[e], and the sensors were not installed over a full 12-month period, it is not possible to determine whether observed property conditions were due to under- or over-occupancy, or seasonal differences. For this reason, it is not suitable to draw out headline findings on internal property conditions from this pilot.

Nonetheless, the data collected by the sensors does enable us to identify and draw out properties which exhibit unusual property conditions. These are explored in further detail below.

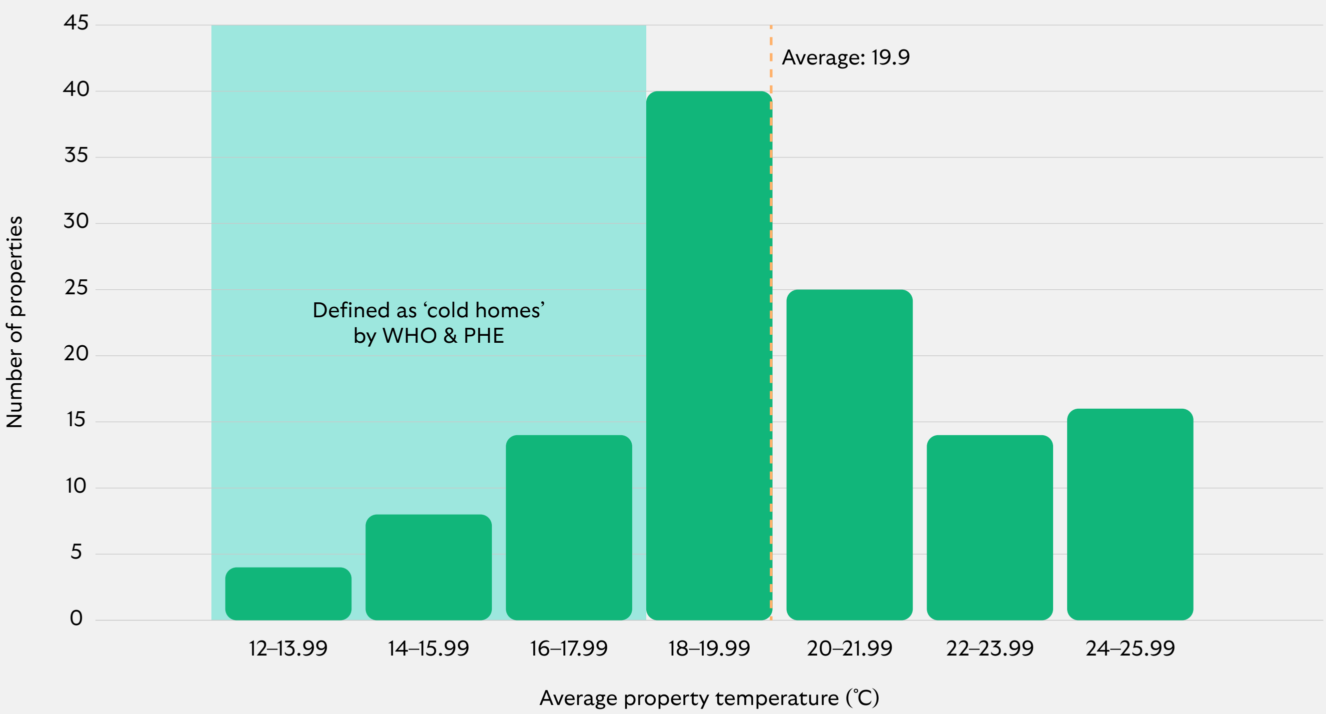
Internal temperature

Across the sample, **26 properties (22%) had an average internal temperature of below 18°C**. These homes would be defined as 'cold homes' by both the World Health Organisation (WHO) and Public Health England, as homes maintained at such temperatures are likely to affect the health and wellbeing of inhabitants.[40]

It is difficult to assess for certain whether these homes are in fuel poverty given we did not receive occupancy data. However, analysing the data further can provide some indication. Of the properties with an average temperature below 18°C, their average measured daily energy use (including gas and/or electric) during the measurement period was 54% less than the daily energy use of the properties with an average temperature of more than 18°C, with sensors installed over the same period.

This suggests that the inhabitants of these colder properties are generally turning on their heating less than other residents. It seems reasonable to assume that there is a high likelihood this is due to these households struggling with energy bills and therefore they could be assumed to be experiencing 'fuel poverty'.

Figure 7: Distribution of measured average property temperature



[e] Although no occupancy data was provided, all properties in the pilot sample were tenanted. What cannot be determined is the level of occupancy during the measurement period – for example, whether residents were present throughout or absent for extended periods.

Internal humidity

Recommended humidity levels vary across seasons, but industry bodies suggest that the recommended indoor humidity range for a UK home is somewhere from 30-60%, with an average of 50-55% as a suitable target.[f] High humidity (above 60%) can lead to damp, mould and mildew growth, and potential respiratory issues, while low humidity can cause issues such as dry skin, cracked lips and sore throats.

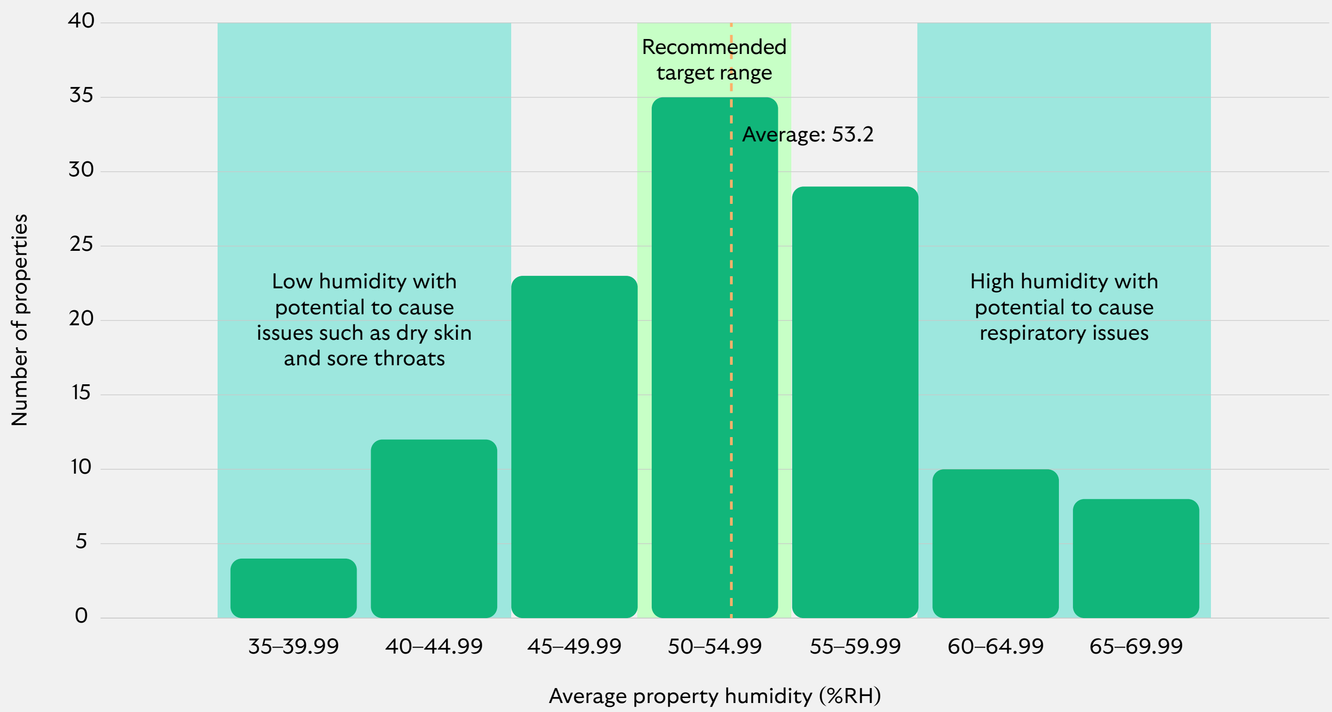
Focusing on high humidity as the issue which has the potential to contribute to more serious long-term health conditions, the measured data shows that **18 properties (15%) have average humidity above 60%**.

It is also worth noting that the measured data enables analysis of the link between temperature and humidity, which can provide valuable insights. As is to be expected, the colder properties (i.e. those below 18°C) had higher average humidity levels (58%) vs the remainder of the sample portfolio (52%).

There are also several properties which stand out as demonstrating worrying conditions for inhabitants. Within the sample, there was a set of four very cold properties (under 14°C) with average humidity levels above 60%. A home with low average temperature, but high humidity, is generally considered a sign of poor living conditions which can have a negative effect on health.[41] Therefore, this is a worrying sign that damp and mould are likely to be present at these four properties. This is especially important given impending legislation (Awaab's Law) which mandates that social landlords must address health hazards like damp and mould within specific timeframes.[42]

Understanding this type of property condition is a crucial first step to identifying the most suitable course of action. Measured data can provide housing associations with a useful high-level screening tool to identify properties that may require further investigation for potential health and safety actions as well as potential retrofit measures. If the measured data shows that properties exhibit worrying internal living conditions, it is essential to deal with those first before considering potential retrofit options. Not doing so has the potential to lead to unintended consequences and to exacerbating problems rather than remedying them.

Figure 8: Distribution of measured average property humidity



[f] In the summer, ideal indoor humidity is 40-60%, while in winter it is 30-50%.

Energy use and carbon impact

Estimated primary energy use

The average annual primary energy use across the sample of properties was estimated at **129 kWh per m²**.

This is marginally below the average for the social housing sector, which is estimated at 134 kWh per m² per year.[43]

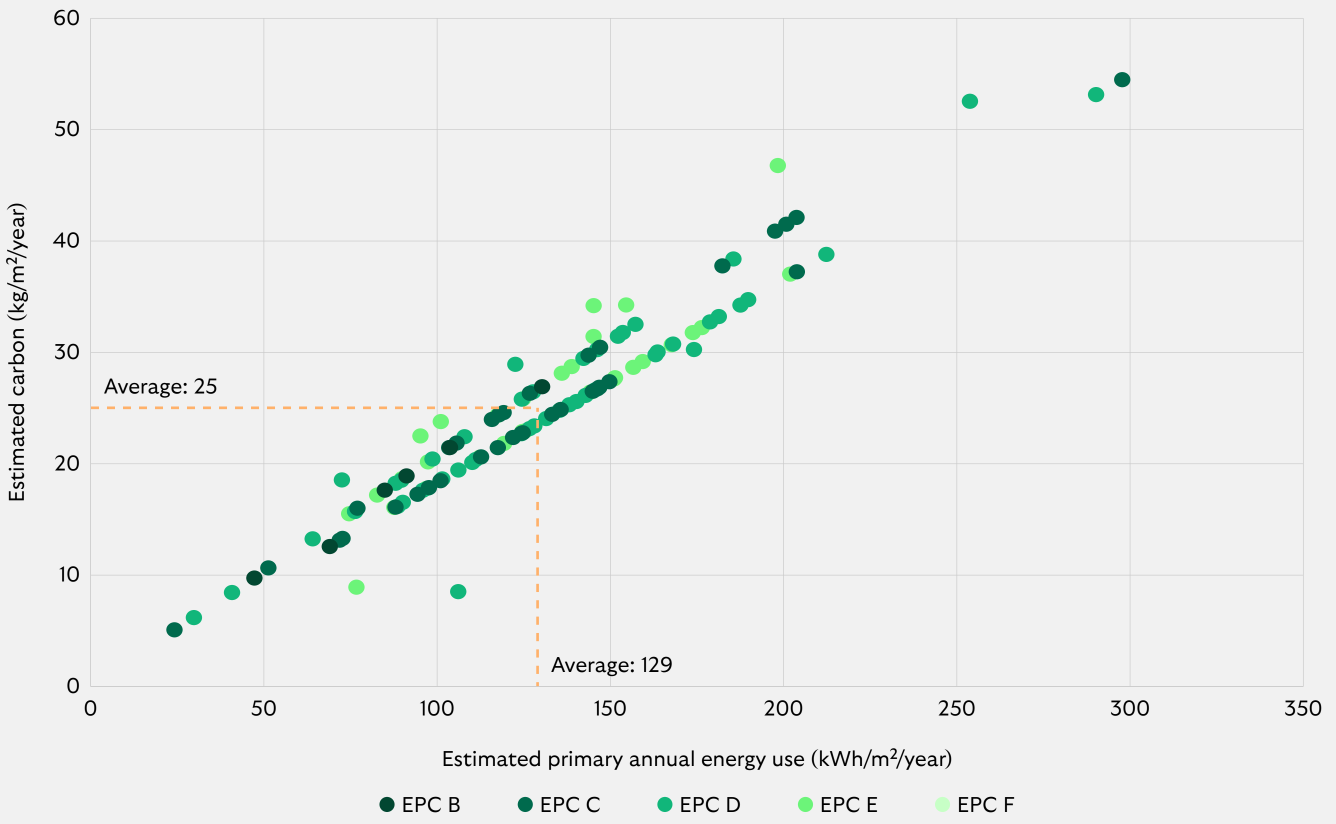
Within the sample portfolio, it is worth noting that the average figure masks significant variation – the lowest estimated annual primary energy use stood at 24 kWh per m², while the maximum was 298 kWh per m². The property with the lowest estimated energy use is a post-retrofit property that has had substantial works, including wall insulation, new windows and an air-source heat pump. In contrast, those properties with the highest estimated energy use are generally those with poor levels of thermal performance and higher peak heat loads.

Estimated carbon emissions

The average annual operational carbon emissions for the sample of properties was estimated as **25kg per m²**.[g]

As is to be expected, the estimated annual carbon emissions have a high degree of correlation with the estimated annual energy use (correlation coefficient = 0.95). However, there are several interesting cases where the level of correlation is significantly lower. This applies to three properties in particular where estimated carbon emissions are approximately half of what would be expected based on the estimated energy use. This was observed at properties that had more efficient heating systems (for example, heat pumps).

Figure 9: Estimated carbon vs estimated primary energy use per year (by stated EPC band)



[g] There is no published average for the social housing sector for this measure.

Thermal performance

Heat transfer

The Heat Transfer Coefficient (HTC) is a key metric used to assess the overall thermal performance of a building. It measures the rate at which a building loses heat through its external envelope (walls, roofs, windows), measuring the rate of heat loss per degree of temperature difference between inside and out.

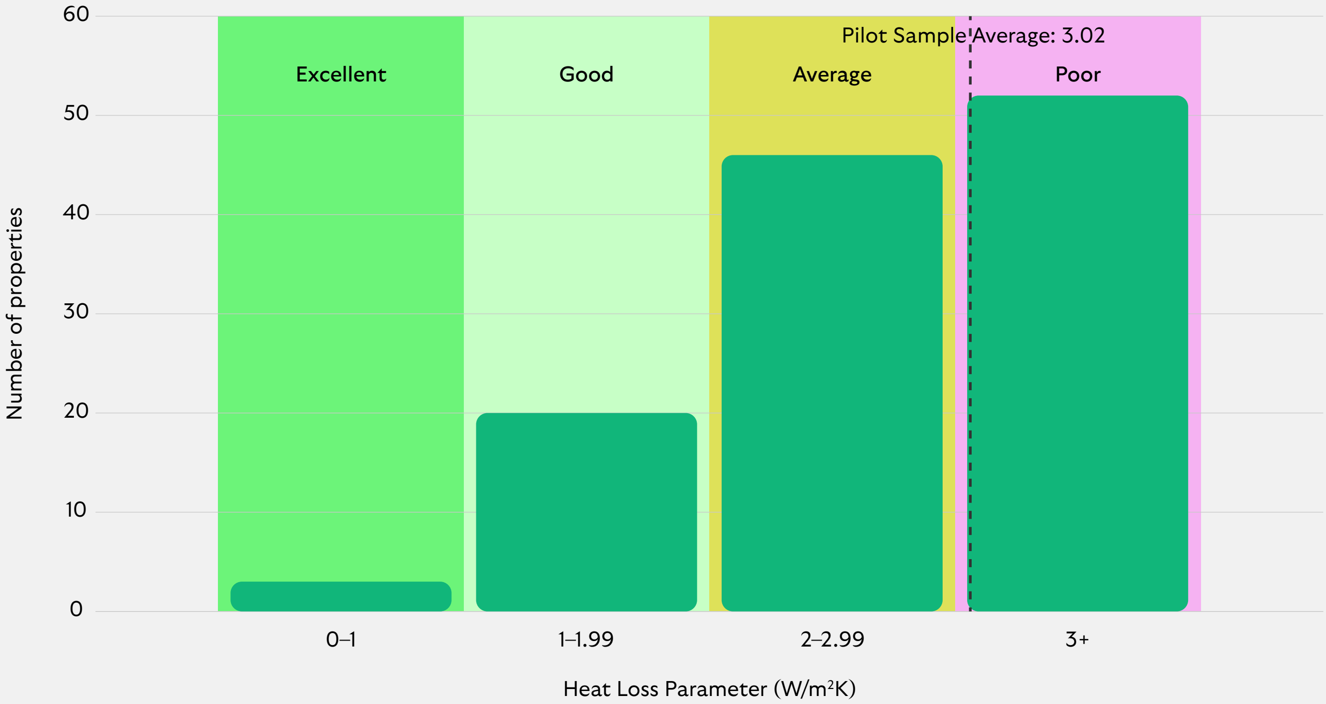
This can be normalised into a metric called the Heat Loss Parameter (HLP), through dividing the HTC figure by the total floor area of a property. This enables a direct comparison between different properties.

For the sample of properties included in the pilot, the average HLP was **3.02 W/m²K**.

Within the sample, the best-performing property had a HLP of 0.5, while the worst-performing property had a HLP of 8.3.

Any home with a HLP over 3 is generally considered to be performing poorly against this key metric.[44] Across the pilot sample, 51 properties (42%) are above this threshold, suggesting significant scope for retrofit works to improve their performance. Yet interestingly, it also shows that over half of the portfolio (58%) is average or better in terms of its thermal performance. For these properties, this finding calls into question whether a 'fabric first' approach would be the correct approach to any retrofit works, given the properties' existing levels of thermal performance, at least in the short-term. For longer-term planning, aiming to achieve a HLP of at 2 or lower would be more appropriate to ensure properties meet the performance threshold of 'Good'. This implication is explored in further detail below, including consideration of the correlation between age of buildings and their thermal performance.

Figure 10: Distribution of Senze-measured Heat Loss Parameter



Peak heat load

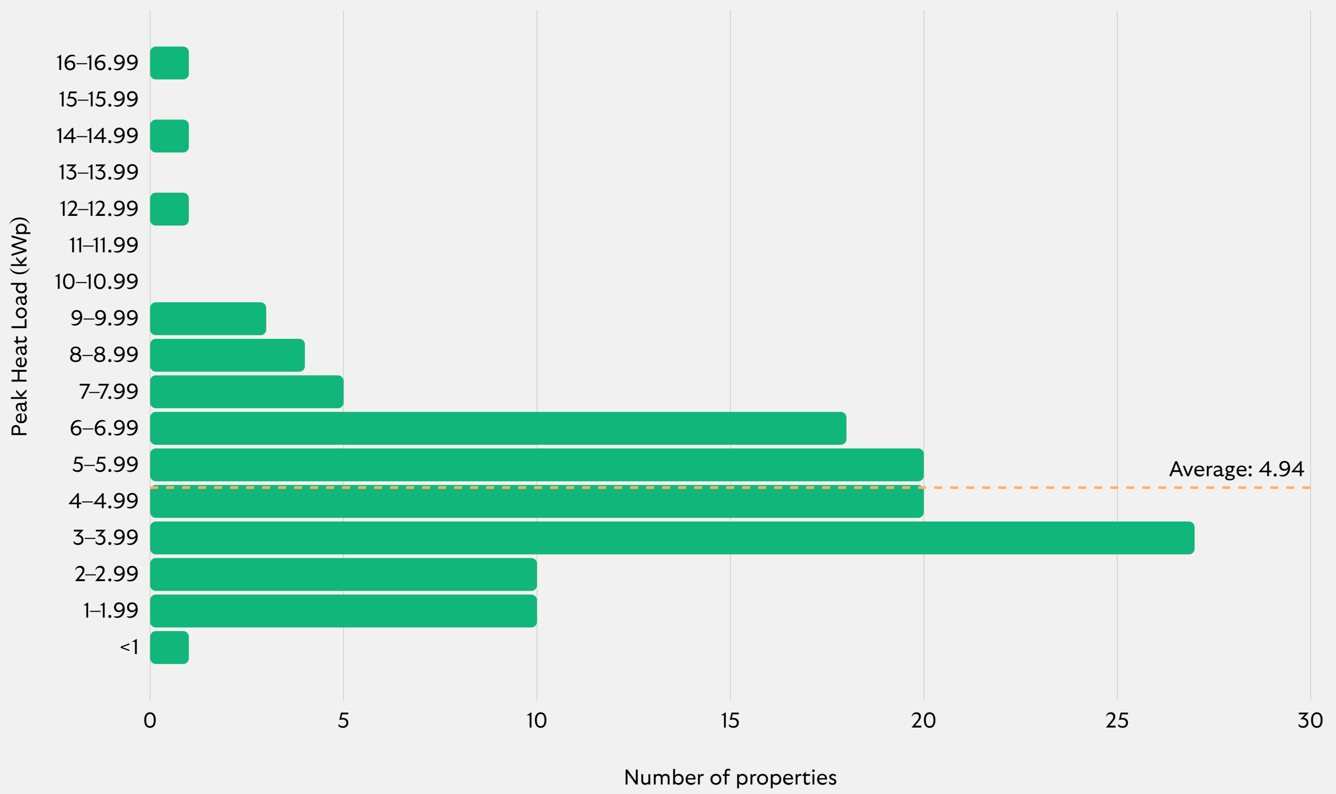
Peak heat load refers to the maximum amount of heat a property requires to maintain a comfortable indoor temperature during the coldest conditions.

For the properties included in the sample, the average peak heat load was **4.94kWp**.

Within the sample, it is worth noting that 61 properties (56%) have a peak heat load of less than 5kWp, and there are only 3 properties (2%) with a peak heat load exceeding 10kWp.

This finding is particularly useful to enable Bromford Flagship to plan, scope and right-size its retrofit interventions to support low carbon heating. One observation during the pilot project was that, to date, Bromford Flagship's heat pumps have mostly appeared to be relatively large, sized at 10kW. Yet the data shows that, for the majority of properties, a 10kW heat pump would be oversized and so not required based on its peak heat load. This has potentially important implications in terms of cost-savings and embodied carbon savings.

Figure 11: Distribution of peak heat load



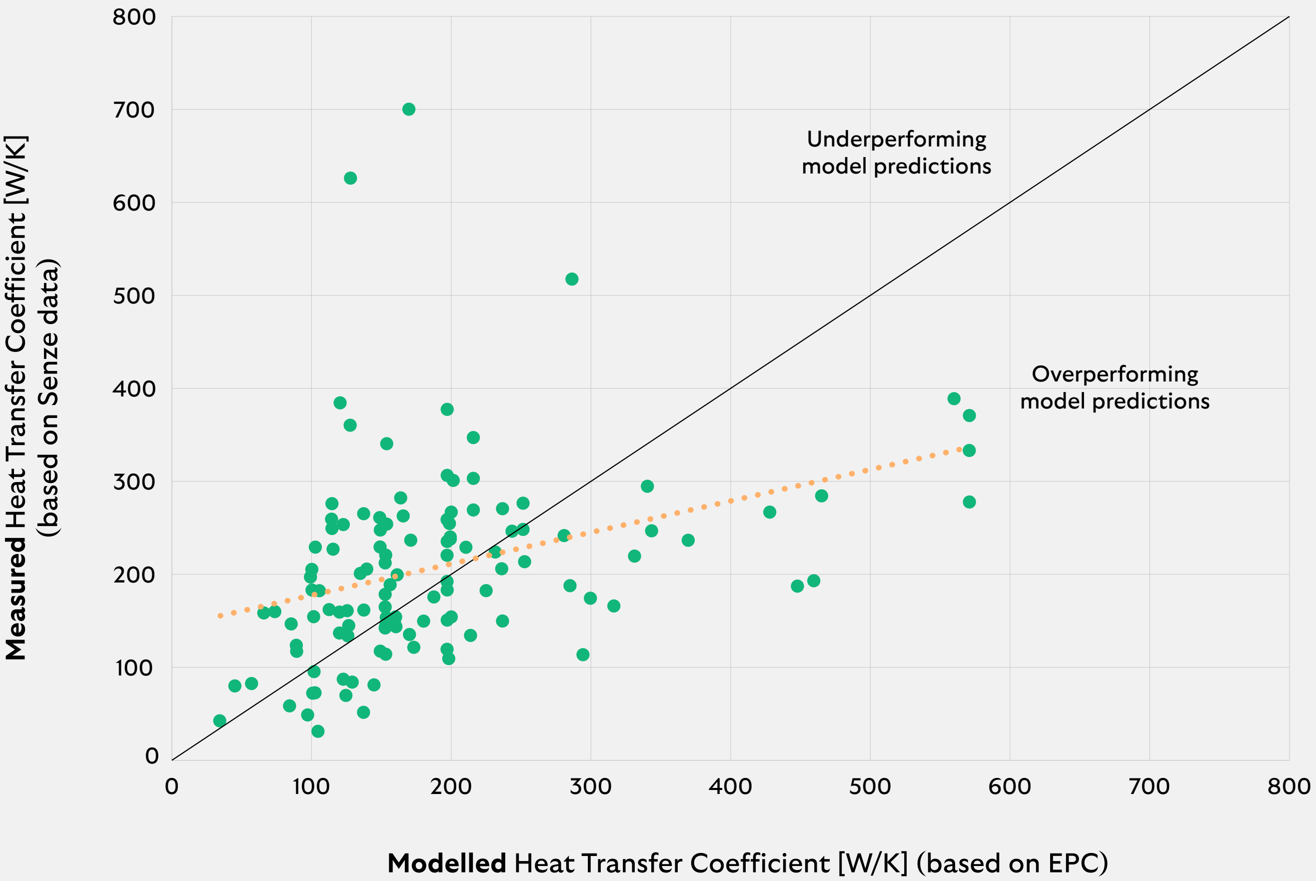
Measured vs modelled performance gap

A stark finding from the measured data collected during this pilot project is that, as other studies have found, EPCs do not appear to provide a wholly accurate measure of a building's thermal performance. This is evident through analysing the difference between 'measured vs modelled' SAP scores (the scoring system underpinning the EPC rating) and the 'thermal performance gap' observed across the sample of properties.

The thermal performance gap is measured by calculating the difference between the modelled HTC based on the property's stated EPC rating, and the equivalent measure based on the data collected by installed sensors. The correlation coefficient between these two measures was only 0.36.

The chart below demonstrates the correlation between the sample portfolio's modelled vs measured HTCs. The perfect diagonal line has been added to demonstrate perfect correlation, with all data points above the line showing properties that underperform their modelled expectations (i.e. they lose heat more quickly than expected), and all data points below the line showing properties that outperform (i.e. they lose heat less quickly than expected).

Figure 12: Measured vs Modelled Heat Transfer Coefficient



Across the sample properties included in the pilot, the average thermal performance gap between these two measures was 25%. This means that, on average, the properties included in the sample are under-performing their model predictions by 25% - they are losing heat, on average, 25% more quickly than their EPCs predict that they should.

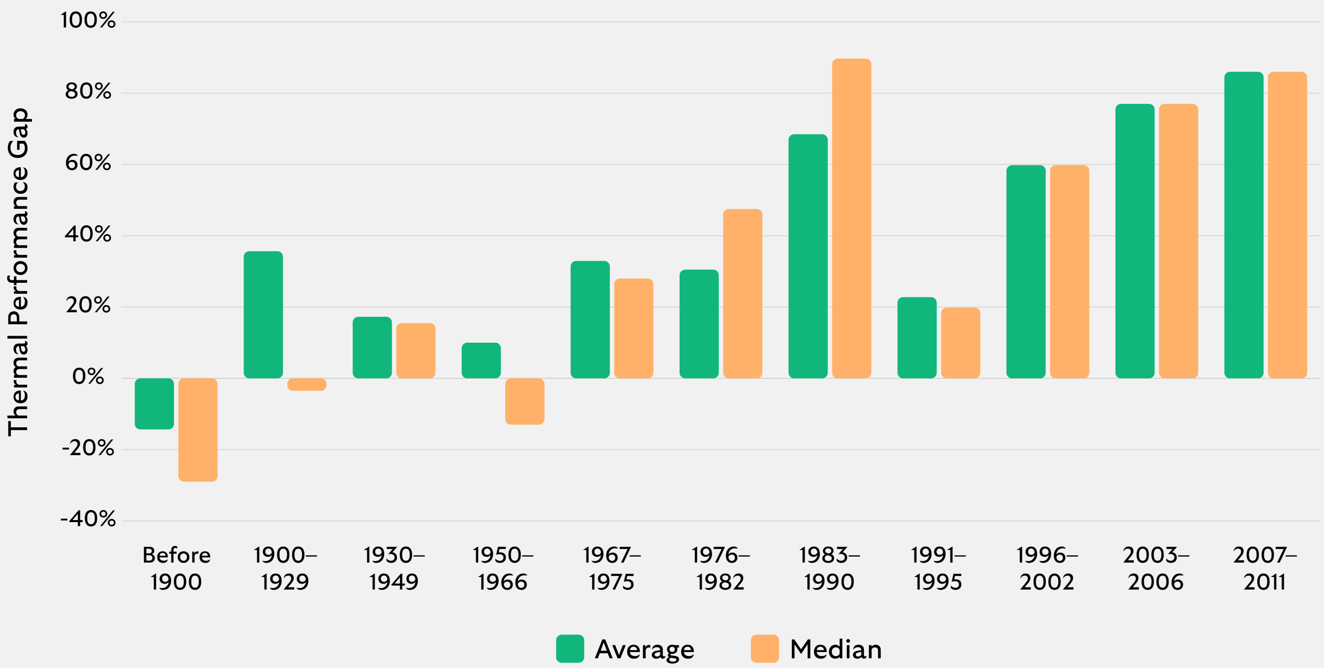
However, within this sample, there was a wider degree of variation:

- 54 properties (45%) had a negative thermal performance gap, meaning they were outperforming their modelled predictions.
- 67 properties (55%) had a positive thermal performance gap, meaning they were under-performing their modelled predictions. Within this set, there were also several properties which stand out as having significantly worse thermal performance than their modelled predictions – 13 properties (11%) had a gap higher than 100% (meaning they lose heat at least twice as quickly), with two properties higher than 300%.

Considering the accuracy of EPCs as a measure of thermal performance, it is noteworthy that, across the pilot sample, there were only 43 properties (36%) with a thermal performance gap within +/-25% of their modelled HTC. This means that the remaining 78 properties (64%) were significantly over- or under-performing their modelled predictions. This suggests that EPCs do not provide an accurate prediction of a building's thermal performance, which is a view which has been supported by existing academic research.[45]

Analysing thermal performance against the age of the properties also revealed noteworthy trends. The data showed that, on average, the older properties included in the pilot sample tended to overperform against their modelled predictions more than newer properties (or at least the older properties were closer to their expected thermal performance). Admittedly, the sample size is small, particularly for the newer properties where only a handful were included in the pilot sample. Nonetheless, it remains a notable finding which is worth further investigation. If similar trends are found to be true across larger portfolios, this supports the view that older buildings may require less significant interventions than expected, while newer buildings may require greater attention.

Figure 13: Thermal performance gap vs age of property



Age of Property	Before 1900	1900–1929	1930–1949	1950–1966	1967–1975	1976–1982	1983–1990	1991–1995	1996–2002	2003–2006	2007–2011
Count	3	22	38	27	13	3	4	6	2	1	2

Adding to an emerging body of evidence

When considering the insights outlined above, it is important to note that these findings add to an emerging body of evidence in this area. The sector's collective understanding of the thermal performance gap, including trends, drivers and potential implications, is still at a relatively early stage. However, there have been several studies which have presented significant findings in this area to date. These include:

- **Leeds Beckett University, Quantifying the domestic building fabric 'performance gap'** (2015)
- **Building Performance Network, State of the Nation review** (2020)
- **Department for Business, Energy & Industrial Strategy, Technical Evaluation of SMETER Technologies (TEST) Project** (2022)

Though the specific findings across these studies does vary, one consistent finding across all is the presence of a significant performance gap across a large portion of the sample of properties assessed. This adds weight to the view that EPCs, and their modelled heat loss estimates, often provide an inaccurate picture of a building's thermal performance.

This study aims to add to the emerging body of evidence in this area, unpacking in detail the potential implications of a data-led approach to retrofit, considering environmental, social and economic effects.

Appendix 7: Potential Outcomes

Outcomes for housing associations and stakeholders

Environmental Outcomes

The following list provides a set of key environmental outcomes which have the potential to flow from a technology-enabled, measured approach to scoping and delivering a retrofit programme.

It should be noted that these figures have been calculated by Senze's model for the 'Core Priority' group of properties only, using unit costs from the Green Buildings Tool, with the homes measured against their current performance. We do not have a counterfactual to assess against (i.e. the expected reduction in carbon emissions that could have been achieved if a typical modelled approach to retrofit had been used), therefore assessment against the properties' baseline level of performance is used to frame the assessment.

- **Reduced operational carbon emissions (vs baseline)** – Based on the measured data's recommended interventions, Senze's analysis estimates this could deliver average annual CO_2 savings of 0.97 tonnes per year per property against their current performance. This is broadly in line with the expected result from a typical modelled approach to retrofit, with analysis showing that upgrading a home from an EPC D to a C reduces operational emissions by one tonne of CO_2 per year.[46]
- **Reduced embodied emissions** – One potential point of differentiation between a technology-enabled, measured approach to retrofit vs a typical EPC-led modelled approach is a reduction in embodied emissions. This project's measured data has shown that more than half of the homes in the pilot sample have a peak heat load of less than 5kW. Therefore, for these homes, a smaller 5kW heat pump would be sufficient to meet its heating needs, yet we know that Bromford Flagship has generally been installing 10kW heat pumps at most properties in its existing retrofit programme to date. Given that smaller heating units have a lower level of embodied carbon than larger units, this measured data could enable a meaningful reduction in embodied carbon if rolled out across a wider portfolio.

Outcomes vs trade-offs

A key consideration for any future deployment of this technology is the inherent trade-offs between environmental, social and economic outcomes.

In this pilot, measured EPC C compliance was used as the guiding principle for identifying the most effective works within the current policy framework. However, because EPC ratings are based on running costs, gas boilers can be recommended by the model as the lowest-cost route to EPC C, even though this comes at the expense of greater carbon reduction.

The technology enables retrofit programmes to be modelled around different priorities, including EPC compliance, carbon reduction, energy bill savings, or payback period. If carbon reduction were prioritised as the guiding principle, the recommended interventions would clearly differ significantly, delivering greater emissions savings.

This flexibility is a clear strength of the approach, but it also illustrates the unavoidable trade-offs that must be managed when balancing environmental, social and economic objectives.

Social Outcomes

The following list provides a set of key social outcomes for residents (as identified in the Theory of Change) which have the potential to flow from adopting a technology-enabled, measured approach to scoping and delivering a retrofit programme:

Increased affordability, leading to reduced fuel poverty has potential to be achieved through:

- *More targeted tackling of inefficient homes* – measured data can enable housing associations to identify the properties that are most in need of retrofit to improve their thermal performance, based on their measured data. Effectively, this means identifying the properties with the worst thermal performance, and prioritising these homes for retrofit works. This also includes identifying the properties in the purple 'home health priority' group, as measured data demonstrates that these properties require retrofit based on their measured performance even though stated EPC ratings would have suggested that they do not need it as they're rated EPC C or higher. Without the measured data, such households may be stuck living in inefficient homes as they would be likely to fall out of scope for any planned retrofit works (indeed many of them have already been through retrofit works, but the data shows this has been ineffective in improving their thermal performance to the expected standard).
- *More targeted tackling of fuel poverty* – measured data can enable housing associations to identify households which may be suffering from fuel poverty, based on the internal property conditions (i.e. those with low temperatures) and/or recorded energy use. For example, this pilot project showed that, of the properties with an average temperature below 18°C, their average measured daily energy use (including gas and/or electric) during the measurement period was more than 50% less than the daily energy use of the properties with an average temperature of more than 18°C. The measured data would enable housing associations to identify and engage such households.
- *Reduction in energy bills (increased affordability)* – based on the measured data's recommended interventions, Senze's analysis estimates average annual energy bill savings of £715 per property (for the 'Core Priority' group only, using unit costs from the Green Buildings Tool, measured against their current performance).

  We feel, however, that this figure should be treated with caution. It is modelled on expected energy use, and evidence from other studies suggests that actual savings are often lower. In the social housing context, many households experience fuel poverty (as the measured data gathered for this project has shown). Therefore, even if thermal efficiency improves, residents struggling to afford bills may continue to under-consume energy, limiting cost-savings.[47] Indeed, a recent government evaluation of Whole House Retrofit and the SHDF found some residents reported no reductions in bills following retrofit funded through SHDF.[48]

Improved wellbeing has potential to be achieved through:

- *Improved home comfort* – through the insights generated by the measured data, housing associations could better target those properties and the works that will be most effective in addressing home comfort issues. This has the potential to contribute to ensuring homes are healthy, efficient and resilient, including, for example:
  - Targeting retrofit works and/or resident engagement at properties that exhibit living conditions which are likely to affect wellbeing and long-term health (e.g. properties with very low temperatures and/or high humidity). This is also important in the context of Awaab's Law, and the requirements placed on landlords to address such issues.
  - Not over-insulating properties where the measured data shows that their thermal performance is better than expected (i.e. the properties in the blue 'compliance priority' group which have a stated EPC rating of D or worse, but measured data shows that they perform like an EPC C or better). Evidence shows that insulating such properties without adequate ventilation interventions can contribute to issues with damp and mould. Utilising measured data should enable housing associations to implement the necessary measures to prevent such issues.
  - Targeting retrofit works at properties where measured data reveals poor thermal performance (despite an EPC rating of C or better) enables identification of homes that would typically fall outside the scope of standard retrofit programmes. These may include properties that have already undergone retrofit but still underperform, highlighting the limitations of relying solely on EPC ratings. By using measured data, it becomes possible to direct further or more targeted interventions where they are genuinely needed, delivering health and wellbeing benefits for residents who might otherwise continue to live in underperforming homes.

- *Reduced resident disruption* – though not meaningfully assessed as part of this pilot study, Senze reports that, on average, nine hours less time was spent on assessment and consultancy by using live data instead of visual inspections and reports.[49] This therefore has the potential to reduce the level of disruption experienced in the retrofit consultation process. Also, where measured data suggests a series of fewer more targeted retrofit interventions (e.g. for a large proportion of the 'Core priority' group) or no retrofit interventions at all (e.g. for the 'Compliance priority' group) this clearly has the potential to reduce resident disruption in the process of carrying out the works through only the most necessary and targeted works being undertaken.

  It must be acknowledged that, for the 'Home health priority' group, there is the potential for greater resident disruption. However, this must be considered against the improvement in home comfort that should result from such works, noting that these homes would have likely remained as inefficient homes with poor thermal performance without the measured data (because housing associations would have assumed they were performing efficiently based on their stated EPC ratings).

Improved long-term health has potential to be achieved through:

- *Improvements to health* – evidence shows that housing refurbishments and modifications, including provision of adequate heating, and improvements to ventilation and insulation are associated with improved respiratory outcomes, quality of life and mental health for residents.[50] Therefore, if housing associations can use measured data to more effectively identify, scope and deliver targeted retrofit works, it is reasonable to assume that this should be associated with improvements to the long-term health of residents. Housing associations could choose to actively prioritise this area through using the measured data in combination with accepted guidance on healthy living environments (e.g. guidance from the World Health Organisation or Public Health England) to identify and guide its decision-making. In effect, this would mean prioritising interventions and modifications to homes so that they fall within the thresholds recommended by such organisations to prioritise long-term health.

Resident Voice

Two residents were interviewed during the installation of the sensors as part of this process. The following quotes were provided. These have been mapped to the expected benefits that residents are hoping to experience as a result of this process:

- **Expected benefit – reduced resident disruption & improved understanding of the process:**
  - "This process has not been disruptive at all. They came in, they talked me through what they were going to be doing today. They were literally in and out within 30 minutes."
- **Expected benefit – reduced energy bills:**
  - "The main benefits I'd hope to see is cutting costs in my energy bills."
  - "I'm hoping that the main benefits for me are going to be a reduction in my energy bill."
- **Expected benefit – improved understanding of how to manage the home effectively**
  - "I'm really interested to know how the home works – is there anything I can do to help it work? Does it need the windows opening? My daughter's room gets quite cold so I'm really intrigued to see if there's anything I can do to warm it up."

It should be noted that these benefits are prospective, as the retrofit works have not yet been undertaken. Nonetheless, they offer valuable insight into residents' anticipated experience of the installation process and help to identify which benefits are likely to be most meaningful from their perspective once the works are delivered. From a policy perspective, this underscores the importance of incorporating resident feedback and priorities into retrofit programme design, ensuring interventions not only achieve technical performance standards but also deliver tangible benefits to households.

This feedback has been factored into the Impact Assessment Plan outlined on p.35.

Economic Outcomes

The following list provides a set of key economic outcomes which have the potential to flow from adopting a technology-enabled approach to scoping and delivering a retrofit programme. These are broken down according to the four quadrant groups outlined previously. Appendix 10 provides further details on the methodology underpinning these calculations.

It is worth noting that the potential economic benefits outlined below arise from calculations based on a small sample of properties. Further research is required to substantiate the findings. Also, there were several limitations identified in relation to the analysis, which must be considered. These included, for example:

- Difficulties obtaining independent costings data for retrofit interventions, noting that this was eventually resolved using data provided by CFP's Green Buildings Tool.
- Substantial differences in the stated unit costs and planned spending between Bromford and Flagship in their original retrofit programmes as a result of a fundamental difference in approach. This has a significant impact on the scale of cost-savings that could be realised.
- The sample of properties that could be included in the cost comparison was smaller than the full pilot sample. This was due to the need to ensure a meaningful counterfactual was available between properties at the same stage of retrofit.

Further detail is available on the challenges and limitations encountered in relation to the cost comparison, and the pilot project in general, in subsequent Appendices.[h]

Group 1 – Core priority (59% of pilot sample)
Properties with an EPC rating of D or worse, confirmed by measured data.

Based on 27 properties for which there is meaningful cost-comparison data, we estimate that making use of the data and implementing Senze's recommended retrofit interventions could generate cost-savings of **£340,000** vs what Bromford Flagship was planning to spend through its traditional approach. This is based purely on the cost of carrying out the interventions (i.e. it does not include preliminary/co-ordination costs).

On average, this equates to a saving of over **£12,500** per property. This outcome is achieved through targeted interventions tailored to the specific needs of each property, rather than typically applying a blanket fabric-first approach, which can lead to unnecessary measures.

There are also further potential cost savings to consider which could be realised based on a more commercial approach to procurement. While commercial retrofits can achieve cost-efficiencies through economies of scale, residential retrofits are often fragmented and costly to carry out.[51] In particular, housing associations are often required to rely on subcontracting arrangements, layering on additional management and procurement costs.

This was observed even within the confines of this project, where wide variation in cost figures was reported by the two housing associations involved. To date, Bromford have generally undertaken a deep, turnkey, whole house retrofit approach at a relatively higher cost, appointing a main contractor to provide an end-to-end package. In contrast, Flagship have generally adopted a package of smaller, more incremental measures at lower cost, delivering large elements of the process internally.

To account for this, we therefore ran a second cost comparison, using unit cost data provided by the CFP's Green Buildings Tool, as a wholly independent source (see Appendix 10 for further details on the cost comparison methodology and the Green Buildings Tool). This enables insight into the full potential cost-savings that could be realised if housing associations were able to procure retrofit services in a more commercial manner, as well as carrying out more targeted retrofit interventions, as facilitated by an intelligent measured data approach. Factoring in both of these elements, the analysis identified potential cost savings of over **£27,500** per property compared with Bromford Flagship's original budget, based on the Green Buildings Tool's independent unit costs.

[h] See 'Appendix 9: Challenges and Limitations' and 'Appendix 10: Cost Comparison Methodology' in the Appendices for further details.

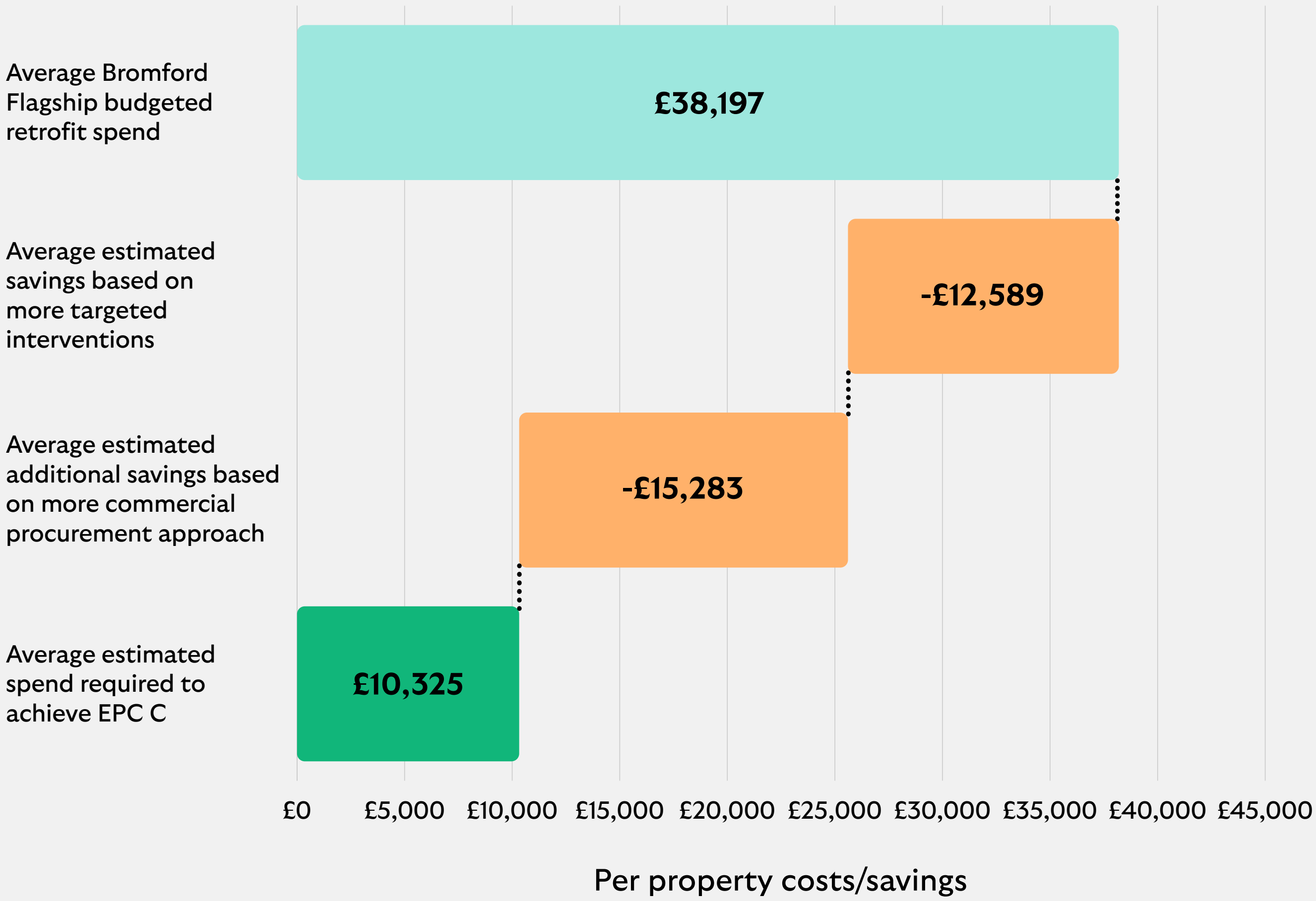
CFP's Green Buildings Tool costs

The investment figures used in this report are derived from the CFP's Green Buildings Tool (GBT). These figures are based on a comprehensive library of sources collated over multiple years, combining actual contractor quotes with desk research. Costs include both materials and labour, but exclude VAT. The figures are reviewed and externally validated annually, with the most recent validation completed in July 2025. It is important to note that actual costs will depend on the details of each specific home and can differ from situation to situation.

While it is beyond the scope of this pilot to explore in detail, this is an area that warrants further research given the implications for public funding frameworks and housing associations' procurement.

The graph below shows the breakdown of these potential savings for the average property in this group. Note that the estimated savings account for the £1,500 cost of deploying the intelligent measured data approach.

Figure 14: Core Priority potential cost savings



Group 2 – Compliance priority (7% of pilot sample)
Properties with an EPC rating of D or worse, where measured data indicates performance of EPC C or better.

Based on four properties for which there is meaningful cost-comparison data, we estimate that making use of measured data could generate cost-savings of over **£165,000** vs what Bromford Flagship was planning to spend through its traditional approach on these properties.

This equates to around **£41,000** saved on average per property. This is generated through not carrying out any retrofit works to these properties, since the measured data shows that they are already performing as an EPC C equivalent or better.

Based on this data, housing associations may choose to defer retrofit works on these properties in the short term, pending potential policy changes that would allow 'measured data' to inform EPC ratings (noting the consultation is due to release its decision in 2026). If that happens, these properties could become EPC C compliant based on the data collected for this project, meaning no interventions would be required.

There are also potentially important social benefits to be realised for this group of properties, based on the insights generated by the measured data, through reducing resident disruption.

Group 3 – Home health priority (13% of pilot sample)
Properties with an EPC rating of C or better, where measured data indicates performance of EPC D or worse.

For a proportion of these properties, the evidence indicates a risk that retrofit resources have not delivered the expected improvement in performance as yet. Several homes have either already undergone, or are currently undergoing, retrofit works yet continue to perform below EPC C based on measured data, notwithstanding their modelled EPC C rating. This implies that expenditure has not delivered the intended performance gains – an issue with implications not only for housing associations but also for residents and financial institutions providing retrofit finance.

Among the nine properties with cost data available, Bromford Flagship has already spent approximately **£243,000** in total, equating to an average of around **£27,000** per property.

Clearly, if Bromford Flagship now decided to undertake further retrofit works to improve the performance of the properties based on this data, then this would result in additional expenditure vs what it would have spent. However, we are unable to provide a cost comparison for these properties against Senze's recommended interventions based on the properties' measured data. This is because underperformance cannot be resolved solely by adding additional energy-saving measures. The issues may stem from mis-specified fabric or systems, and could require further investigation, upgrades, workmanship checks, or even removal and replacement to address the underlying performance issues.

If these properties' underperformance is attributable either to inadequate or substandard installation quality, then a measured data-led approach to retrofit does not offer a point of differentiation. However, if underperformance is due to inappropriate interventions, such as installing insulation unnecessarily or prioritising efficiency measures over essential fabric improvements, a measurement-led approach could help to avoid such costs. By assessing actual thermal conditions and fabric performance upfront, interventions can be more accurately targeted.

The results for this group of properties also demonstrates the value that monitoring technology could play in post-occupancy evaluation, to check if interventions have delivered the expected improvement in a property's performance.

It is worth noting that we do not have data on how these properties were performing before any interventions were carried out. Therefore, there may have been an improvement from the baseline, although the measured data shows that, if there has, it has not been sufficient to improve the measured performance of the properties to the equivalent of an EPC C or better.

Group 4 – No retrofit required (21% of pilot sample)
These properties are rated EPC C or better and measured data confirms that they perform as such.

No retrofit required at these properties. Therefore, there are no significant economic implications to be realised for this group of properties.

It is worth noting, of the 25 properties included in this group, 23 are categorised as mid-/post-retrofit. For the 15 properties in this group where comprehensive cost data is available, Bromford Flagship has spent an average of around £25,000 per property on retrofit measures to date.

At these properties, measurement still provides a valuable role to determine whether properties that are rated EPC C or higher sit in Group 3 (Home health priority) or Group 4 (No retrofit needed).

Overall, analysis across the four groups suggests that investing in technology to generate measured rather than modelled performance data can prove cost-effective, with potential savings outweighing the cost of measured data technology deployment in most cases. This is in addition to the potential environmental and social benefits which could be realised through deployment.

However, it should be noted that the potential cost-savings stated in this report could be inaccurate as they are primarily based on a comparison against Bromford's original programme of retrofit works (as Bromford's original portfolio formed the majority of the pilot sample). To date, Bromford has typically undertaken a deep, whole house approach to retrofit, whereas Flagship has undertaken more incremental measures at a lower cost.

Though the sample sizes were small when isolating and comparing the relative cost-savings against Bromford or Flagship's previous retrofit programmes, the data still shows that the technology has the potential to generate cost-savings across both samples. It is, however, notable that the scale of the savings is reduced when assessing only Flagship's properties. This is largely to be expected given Flagship's more incremental approach to date.

Overall, these findings substantiate the point that there are significantly different approaches to retrofit that housing associations can choose to take. It also demonstrates the value that technology could play in enabling housing associations to come to a better understanding of the most relevant retrofit measures.

It is encouraging that the data shows that the technology has the potential to generate cost-savings for housing associations who have typically adopted a deep retrofit approach, as well as those implementing more incremental measures. Yet noting the differences in the scale of potential cost-savings, this is clearly an area that requires further research.

Appendix 8: Impact Assessment Plan

As noted, this pilot project has been described as a 'Demonstrator' study. This is because it is forward-looking – at the time of writing, the technology has been used to collect baseline energy and thermal performance data on the homes, and to provide recommended works and costings to upgrade their performance. However, the works themselves have not yet been carried out.

Therefore, we are unable to assess the actual benefits associated with executing a retrofit programme based on the recommendations arising from the deployment of such technology. However, we can outline a suggested Impact Assessment Plan. This plan outlines the metrics and insights that we suggest should be monitored to assess the effectiveness of a retrofit programme which is scoped, planned and executed based on the property-level data and recommended interventions provided by such technology. We suggest this plan should be utilised in the future to test if 'the theory' outlined in this report, and as summarised in the Theory of Change, has played out 'in practice'.

Area	Outcome	Measures
Environmental	**Reduced carbon emissions**	• Reduction in estimated carbon emissions • Improvement in measured EPC rating (vs baseline) • Improvement in heat transfer coefficient (vs baseline)
Social	**Increased affordability, leading to reduced fuel poverty**	• Average primary energy use (vs baseline) • Average estimated fuel bills (vs baseline) • Number of households identified as at risk of fuel poverty based on measured property-level data (and then number subsequently engaged with)
	Improved wellbeing	• Resident sentiment towards retrofit process (based on resident survey) • Average length of time properties spent undergoing retrofit works (benchmarked vs sector average) • Average assessment and consultancy time per property (benchmarked vs sector average based EPC-led approach)
	Improved long-term health	• Percentage of homes with property conditions in line with WHO/PHE guidelines on internal temperature and humidity (vs baseline) • Number of households identified as at risk of experiencing damp and mould based on measured property-level data (and then number subsequently engaged with/cases rectified)
	Green skills and creation of local jobs	• Number of local jobs created in retrofit process (vs baseline)
Economic	**Decision optimisation, leading to improved targeting and reduced cost (and more funding for other purposes)**	• Average amount spent per property (vs previous average based on SHDF-funded approach) • Average payback period (vs previous average based on SHDF-funded approach) • Number of properties that did not undergo retrofit which previously would have based on stated EPC rating being EPC D or worse (but where measured performance shows they perform as EPC C or better) • Number of properties that did undergo retrofit which previously would not have based on stated EPC rating being EPC C or better (but where measured performance shows they perform as EPC D or worse)
	Value for money for the public purse	• Amount of public grant utilised (vs previous average)

Appendix 9: Challenges and Limitations

With the expected outcomes that this project has the potential to deliver, it is worth noting that there have been various challenges encountered during the pilot. This is largely to be expected with the application of any new technology. Nonetheless, they must be addressed when considering the potential scale up and implications of wider adoption of such an approach. Also, by identifying and working through such issues in the context of this pilot, we hope that this will help to mitigate the likelihood or severity of such challenges being encountered in the future.

Challenges encountered have included:

- The sample size was small. Further testing is required across different geographies, property types, and housing association portfolios to validate the scale of potential benefits, both for Bromford Flagship and for the social housing sector as a whole.
- There were several instances of resident pushback regarding the installation of sensor technology in their homes during the pilot project.
- Coordination challenges arose as a result of difficulties accessing a sufficient sample of properties to install sensors that both met the agreed sample characteristics and was of sufficient scale for the pilot project.
- We acknowledge that it is a benefit of Senze's LTMA that the thermal performance of a property can be assessed over a relatively short measurement window and without the need for the property to be vacated (as outlined in the results of the research carried out based on the University of Salford's Energy House research facility). However, for the purposes of this project, this relatively short measurement window means that we are unable to draw meaningful conclusions based on the data collected on internal property conditions, which vary based on occupancy and seasonal effects. Therefore, if the technology was intended to be used for predictive maintenance purposes, or to more effectively identify damp and mould issues, or instances of fuel poverty, this would require a longer measurement window (likely a full year to account for all seasonal effects).
- There were difficulties obtaining suitable independent costings data in relation to retrofit interventions for the purposes of this study. This was specifically related to the project's need to find a robust, independent source of unit cost data to assess the cost differentials of a data-led retrofit approach, plus a more commercial approach to procurement, vs expected costings if adopting a more traditional retrofit approach.
- Some erroneous data points were observed in relation to several properties (three properties in total) during the pilot project. These erroneous findings add to the general question of how measured data and modelled data (i.e. EPCs) could coexist moving forward. For Senze specifically, such findings provide learnings for them as a business in terms of their platform, and how the measured data collected interacts with modelled predictions. See below for details on the specific properties and how they were treated in the report:
  - One property appeared to show issues in terms of how the data was normalised. Senze reviewed the data and indicated that the modelled inputs were likely based on a different building. This property was removed from all analysis in the report relating to measured vs modelled thermal performance, and cost comparisons.
  - Two properties whereby the thermal performance gap appeared to go in the opposite direction to what would be expected based on the measured vs modelled thermal performance. Senze reviewed and confirmed their confidence that the measured data was correct for both properties. They consider this discrepancy was likely to have resulted from erroneous modelled inputs relating to factors that determine a property's energy rating (e.g. system efficiency, geometry, property dimensions) – this points to the potential for human errors in the EPC assessment process. Since Senze are confident that the measured data is correct, these properties remain included in the analysis in the report relating to both thermal performance and cost comparisons.

- There were substantial disparities in the stated unit costs and planned spending between Bromford and Flagship in their original retrofit programmes. To date, Bromford have generally undertaken a deep, turnkey, whole house retrofit approach at a relatively higher cost, appointing a main contractor to provide an end-to-end package. In contrast, Flagship have generally adopted a package of smaller, more incremental measures at lower cost, delivering large elements of the process internally. Clearly, the difference between these two approaches has a significant influence on the potential cost-savings that could be realised through a technology-enabled, measurement-based approach. Further research is required in this area.
- The sample of properties included in the cost comparison calculation was smaller than the full pilot sample. There were 95 properties included in Groups 1, 2 or 3 of the quadrant approach, however only 40 could be included in the cost comparison calculations. This was due to the need to ensure the comparison was meaningful and had a suitable counterfactual to assess against:
  - The properties in Groups 1 and 2 used in the cost comparison needed to be those categorised as ‘Pre-retrofit’ and with a programme of planned and costed retrofit interventions under Bromford’s/Flagship’s original retrofit programmes.
  - The properties in Group 3 used in the cost comparison needed to be those classed as ‘Mid-retrofit’ or ‘Post-retrofit’, with a programme of actual retrofit interventions which have already been paid for and implemented.

Appendix 10: Cost Comparison Methodology

Methodology overview

The basis for the cost comparison methodology used in this report was to compare the recommended retrofit interventions based on the measured data and simulation of Senze's platform against Bromford Flagship's existing programme of retrofit interventions. To enable this cost comparison, two different calculations were run based on cost data provided for this project:

1. Cost data provided by Bromford or Flagship regarding its planned or historic interventions and spending for each relevant property included in the pilot sample.
2. Independent cost data provided by CFP's Green Buildings Tool on the cost of specific retrofit interventions.

For the purposes of this project, it was decided to run two cost comparison calculations to ensure the results were sufficiently robust. It was felt that it was important to run a version of the calculation based on Bromford Flagship's actual costs (planned or historic), because this is clearly based in the reality of what Bromford Flagship has spent historically and what it would have been likely to spend if adopting a typical EPC-led approach to retrofit moving forward (i.e. if not using a measured approach).

However, it was also observed that unit costs and procurement processes can vary significantly between housing associations, and there exists the potential for housing associations to benefit from a more commercial approach to procurement. Therefore, it was also important to run a second version of the cost comparison calculation, based on cost data provided from a wholly independent source. To do so, it was decided to use unit cost data provided by CFP's Green Buildings Tool (further details below).

CFP's Green Buildings Tool

CFP's Green Buildings Tool is a digital energy consulting solution designed to evaluate the energy efficiency of real estate portfolios, as well as individual buildings.

The investment figures provided by CFP for this report are derived from its Green Buildings Tool. These figures are based on a comprehensive library of sources collated over multiple years, combining actual contractor quotes with desk research. Costs include both materials and labour but exclude VAT. The figures are reviewed and externally validated annually, with the most recent validation completed in July 2025. It is important to note that actual costs will depend on the details of each specific home and can differ from situation to situation.

Calculation process

The cost comparison for each relevant property in the sample was calculated by Senze based on the inputs outlined above. The cost comparison database was provided by Senze to TGE for checking. TGE ran selected spot checks on specific properties in this dataset to ensure that the correct properties and costs were being paired together. Based on the information provided, TGE calculated property-level averages for each of the relevant groups contained in the sample.

Historic vs planned spending

It should be noted that the pilot sample portfolio includes properties across the following categories:

- Pre-retrofit – properties earmarked for retrofit, that have had no works undertaken yet.
- Mid-retrofit – properties that have had some retrofit interventions carried out, but not the full programme of planned works.
- Post-retrofit – properties that have already undergone a full programme of retrofit works, funded by Bromford Flagship and government grant funding through the WH:SHF (previously the SHDF).

The actual or planned set of works and spending (depending on which of the groups above each property falls into) was used as the counterfactual against which to assess the potential impact of adopting a technology-led, measurement-based approach to retrofit. This information was provided by Bromford Flagship to Senze and to TGE to inform this pilot study.

Illustrative examples:

For the properties in the sample classed as 'pre-retrofit' – the counterfactual used is Bromford Flagship's planned interventions and spending at these properties (i.e. these works have not yet been carried out). The cost used is the full funding that Bromford Flagship has allocated to each specific intervention. These planned interventions were then compared against the recommended interventions based on the measured data and the platform's simulation of retrofit options. This applies to the cost comparison for Group 1 (Core Priority) and Group 2 (Compliance Priority).

For the properties in the sample classed as 'mid-/post-retrofit' – the counterfactual used is Bromford Flagship's actual interventions and spending at these properties to date (i.e. these works have already been costed and carried out). The cost used is the amount of funding 'claimed to date' by Bromford Flagship for each specific intervention, as this is assumed to relate to works that have already taken place. The spending on these interventions was then analysed against the measured thermal performance data, to assess whether funding had been successful in delivering the expected improvements in performance. This applies to the cost comparison for Group 3 (Home Health Priority).

Figure 15: Cost comparison methodology

The counterfactual:

Bromford Flagship's original planned retrofit spending

Based on Bromford Flagship's property-level data on planned interventions and spending, with costs split out for each property and each relevant intervention. This information was based on the retrofit assessment and planned spending under Bromford Flagship's original retrofit programme, which was expected to be partly funded through the Government's WH:SHF (previously SHDF).

Compared against

Cost comparison 1: Bromford Flagship costs

Expected spending based on Senze's recommended interventions, but utilising Bromford Flagship's planned unit costs for each intervention

This utilises the same unit cost database as the above, but only in relation to the specific retrofit interventions for each property that Senze's measured data has shown are required to meet the equivalent of an EPC C. This comparison was included to isolate the potential savings that could be achieved solely through more targeted interventions.

Compared against

Cost comparison 2: Green Building Tool costs

Expected spending based on Senze's recommended interventions, and utilising the Green Buildings Tool's independent unit costs for each relevant intervention

This utilises an independent unit cost database provided by the Green Building Tool, but is still based on the specific retrofit interventions for each property that Senze's measured data has shown are required to meet the equivalent of an EPC C. This second cost comparison was included to show the full potential cost-savings if housing associations were able to implement a more commercial approach to retrofit procurement, in addition to more targeted interventions, as facilitated by measured data.

Assumptions underpinning the cost comparison methodology

- All costs stated in this section exclude co-ordination/preliminary costs – this refers to all expenses related to the administration and operation of a construction project (e.g. scaffolding, health and safety). Therefore, the costs stated relate only to the cost of the retrofit interventions themselves, including materials, labour and any contractors' overheads.
- Senze's estimated costs include the assessment cost associated with their service, which is £1,500 per property.
- If Senze's measured approach recommends a specific intervention which was not originally budgeted for within Bromford Flagship's planned retrofit programme, then the intervention cost for a similar property has been used instead.
- For all other intervention costs, the stated cost used in the counterfactual and in cost comparison 1 is the full amount budgeted by Bromford Flagship for that specific property.
- There are certain interventions which do not include a stated cost between the two cost databases used. Where this is the case, the stated unit cost from the alternative database is used instead, for example:
  - *Floor insulation* – Bromford Flagship's planned retrofit programme did not include a stated cost for floor insulation. Therefore, in cases where floor insulation is a recommended intervention based on Senze's measured data, the unit cost used is based on the Green Buildings Tool cost for this intervention across both cost comparison calculations.
  - *Ventilation* – the Green Buildings Tool did not include a stated cost for ventilation. Therefore, where ventilation is a recommended intervention based on Senze's recommended interventions, this cost is based on Bromford Flagship's stated cost for this intervention across both cost comparison calculations.

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We aim to provide you with a high level of service. If you have a query our Help & Support pages can help: **lloydsbank.com/business/help**

Important Information

M61726 (10/25)

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