RetroMeter

A Strategic Innovation Fund Discovery Phase Project

WP4 Milestone M3 – Discovery Phase Final Report

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Project Partners:

Carbon Co-op

EnergyPro Ltd

Energy Systems Catapult

Manchester City Council

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Contents

Glossary

Term	Definitions
ASHP	Air Source Heat Pump
DSR	Demand Side Response
DNO	Distribution Network Operator
EE	Energy Efficiency
EPC	Energy Performance Certificate
EUI	Energy Use Intensity
EWI	External Wall Insulation
M&V	Measurement and Verification
MCC	Manchester City Council
P4P	Pay for Performance
PV	PhotoVoltaic
RIIO-ED2	The price control for the electricity distribution networks 2023 - 2028
SIF	Strategic Innovation Fund
SHDF	Social Housing Decarbonisation Fund
WP	Work Package

1 Introduction

The Strategic Innovation Fund (SIF) is supporting network innovation that contributes to the achievement of net zero, while delivering net benefits to energy consumers. Ofgem sets the strategic innovation challenges and invites applications for projects to address them. To mitigate the risk associated with innovation, the innovation is funded in three phases:

1. *Discovery phase (feasibility studies):* define the problem and the value in solving the problem.

2. *Alpha phase (experimental development):* focus on preparing and testing the different solutions identified during the discovery phase.

3. *Beta phase (build, operation and/or demonstration):* focus on the deployment of the solution to the problem.

RetroMeter was submitted as a solution to address the SIF Round 2 Challenge 4: "Accelerating Decarbonisation of Major Energy Demands: Improving energy efficiency at all levels in the system".

2 RetroMeter overview

RetroMeter will provide and demonstrate a standard methodology to accurately measure the energy and cost savings of retrofits, unlocking pay-for-performance (P4P) financing, increasing uptake and leading to reduced costs for consumers and additional flexible services for the DNO.

This discovery phase is being led by Electricity North West, and principally delivered by EnergyPro Ltd, Energy Systems Catapult, Carbon Co-op, supported by Manchester City Council.

This discovery phase project will be delivered through 3 work packages (WP):

- WP1 - Develop a list of available and proposed UK energy consumption datasets, with access plans for each.

- WP2 - Assess output parameters and current state of measurement & verification methods and propose two or three methods for development in the Alpha phase.

- WP3 - Identify barriers to P4P energy efficiency models; develop a least-cost quantitative model to value the benefits to householders, network users and DNOs; and propose and refine three delivery model options for development in the alpha phase.

This report is the Discovery phase final report and provides the high level conclusions from the work carried out in each WP and the recommendations for the Alpha and Beta phases of the project.

3 WP1 - Develop a list of available and proposed UK energy consumption datasets including access plans

WP1 focused on the data required for developing and deploying a metered energy savings solution, what relevant datasets are available, and how they might be accessed. It also considered the practicalities and processes involved in collecting data from households that participate directly in the Beta phase. Below is a summary of the findings – see the WP1 report for more details.

The majority of UK properties are currently gas heated, and so development of the methodology in Alpha and Beta will focus on modelling gas rather than electricity. This limits the data required for methodology development to gas data (plus external temperature). Since gas prices are not time-of-use dependent, this also technically eliminates the need for half hourly data. However, in practice daily data is only available when a smart meter is installed.

Note that testing the accuracy of the counterfactual modelling in Alpha requires data from homes that have not had retrofits performed. This is because the first year of the data is used to develop the counterfactual for the second year, which is then compared to the actual energy use in the second year, with the expected difference being zero for a perfect model – because no retrofit has occurred.

The key data requirement is therefore daily gas data for 2+ years from homes that have not had retrofits performed. This must also be accompanied by external temperature data to allow for variations in weather conditions to be accounted for. This data ideally needs to be representative of UK housing stock so that we can be confident the methodology works well for all housing type and demographic mixes.

Developing and validating methodologies based on data from individual homes typically requires a sample size in the hundreds or low thousands – particularly if the aim is to validate its effectiveness across the entire UK housing stock.

However, given the comparison-based methodology proposed in WP2 (where homes are matched to similar properties that haven't undergone a retrofit to help adjust for external factors like energy price changes), much larger samples are required. This is because the accuracy of this methodology is expected to be quite sensitive to the number of homes available to select matches from. Similar work in the US typically leverages pools of smart meter data from hundreds of thousands of homes, but data at that scale is not currently available in the UK. However, we intend to test how effective those methods are when the pool of homes is 10-20k.

In addition, the development of a physics-based component of the methodology ideally requires some homes with gas smart meter data and known Heating Transfer Coefficient (HTC) (or at least gas smart meter data and internal temperature data). These are not required on the same scale, but ideally several hundred would be available from a range of housing types. However, we have been unable to identify any suitable datasets with known HTC values.

The three key data sources that have been identified as being most suitable for Alpha are:

1. Hildebrand smart meter data – 9-12k homes with >2 years of gas smart meter data (plus weather), accessible for decarbonisation-related research with a small fee (several thousand pounds) to cover processing costs. This will be our primary source of gas smart meter data. A

small number of these homes (~100) may also have internal temperature available and be used for developing the physics-based model.

2. Smart Energy Research Laboratory (SERL) - 13k homes with >2 years of gas smart meter data (plus weather and property information), accessible for public good research but with a complex and lengthy process for access (and the requirement for an academic partner). This will be our backup source of gas smart meter data.
3. Living Lab data – 17 homes with gas and internal temperature data. These will be our backup source for developing the physics-based model.

We have yet to identify a suitable enduring data source for comparison-based methods that would provide ongoing access to smart meter data for the purposes of comparison. Further work on this will be required as part of Alpha.

We have also produced draft data sharing agreement documents which will need adapting further in the Alpha, to be used in the Beta phase of the project. These have been produced from existing documents used by Carbon Co-op for the purpose of collecting data from their trial participants.

4 WP2 - Assess output parameters and current state of M&V methods and propose two or three methods for development in the Alpha phase

WP2 focused on the technical methods that will be developed to measure energy savings as part of RetroMeter. Developing a methodology that is universally applicable would be extremely challenging due to the broad scope of both retrofits and the potential end goals for which a metered energy savings methodology could be used. The aim was to therefore to develop a broadly applicable methodology that would be effective in the most common use cases, and could potentially be extended in future. Below is a summary of the findings – see the WP2 report for more details.

Since the majority of UK properties are currently gas heated, development of the methodology in Alpha and Beta will focus on modelling gas rather than electricity. This allows the evaluation of both fabric-only retrofits on gas heated properties and gas boiler to heat pump retrofits (as long as the energy consumed by the heat pump is directly measured). It has the significant advantage of eliminating the need to develop a half-hourly model, as gas prices are not dependent on time of use.

In addition, requiring internal temperature for a year pre-retrofit poses too significant a barrier to widespread adoption, so methods that require that have been ruled out.

Around half of homes have a smart meter (and therefore should have 13 months of data pre-retrofit), so the core methodology can utilise this – but there needs to be an option for when that data is not available.

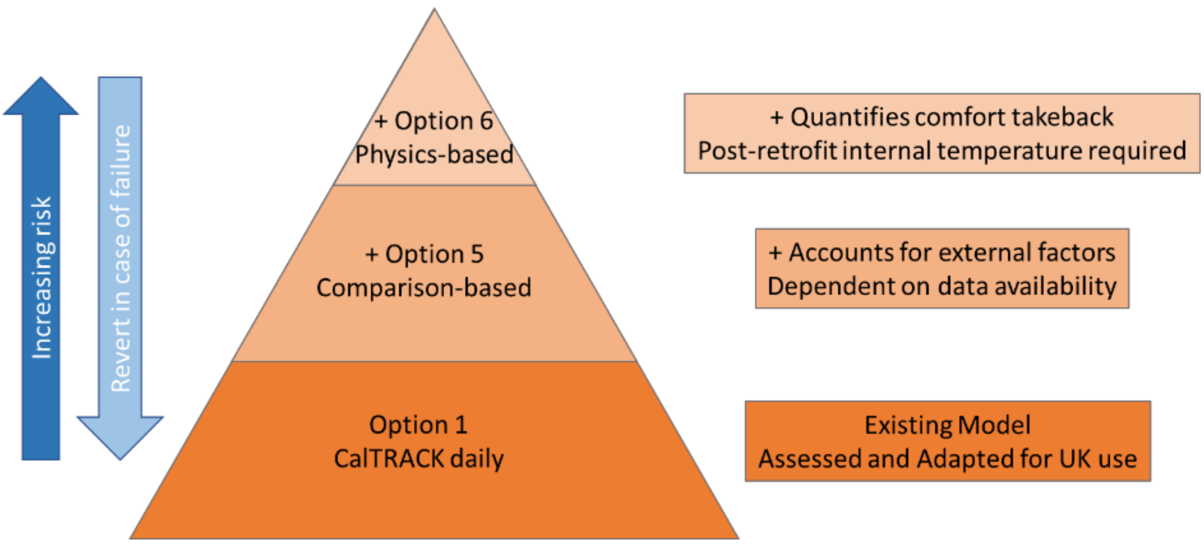
The existing open-source methodology CalTRACK is broadly effective, but because it is dependent on historical energy usage from the same home it fails to account for external changes (e.g. energy price changes and Covid-19) which have been shown to be very important.

Comparison-based methodologies (e.g. GRIDMeter) account for external changes by comparing energy usage to similar homes. However, this is dependent on the availability of lots of smart meter data from homes across the UK to match to, which is not currently available (but may be in future).

Neither of the above approaches account for comfort take-back, which could be a significant factor in overall energy savings, and therefore business models. Direct quantification of comfort take-back could be achieved by combining the above approaches with a physics-based approach. This would require measuring the pre-retrofit heat loss of the property (Heat Transfer Coefficient, HTC) using either smart meter data (for which an algorithm would need to be developed) or a commercial HTC measurement solution (which would eliminate the need for smart meter data). The post-retrofit internal and external temperature measurements would be combined with the pre-retrofit HTC to calculate the counterfactual energy usage given post-retrofit comfort levels. This could be compared to the CalTRACK or comparison-based savings values (which don't account for comfort take-back) to quantify comfort take-back directly.

Method development in Alpha will therefore consist of a layered approach consisting of three components:

1. CalTRACK daily
2. A comparison-based, difference-in-differences approach
3. A physics-based approach that takes post-retrofit internal temperatures and models the pre-retrofit energy usage using an estimated heat transfer coefficient.



This approach mitigates the risks around development and deployment of the comparison-based and physics-based methodologies, whilst hopefully delivering a flexible, scalable approach to metered energy savings that provides the option to account for both external factors and comfort take-back.

Accuracy of these approaches will be assessed using the industry standard metrics (CVRMSE and NBME), with a focus on daily accuracy for individual properties. Alpha phase will also quantify how different sizes of portfolio affect accuracy and uncertainty.

5 WP3 - Identify barriers to P4P energy efficiency models; develop a least-cost quantitative model to value the benefits to householders, network users and DNOs; and propose and refine three delivery model options for development in the alpha phase.

5.1 Literature review on energy efficiency evaluation

Work Package 3, Deliverable 1 produced a literature review on the qualitative estimate of consumer propensity to engage with projects like Retrometer, and explored the different values of residential energy efficiency in terms of total value and cost-effective value at the scale of the Great Britian system.

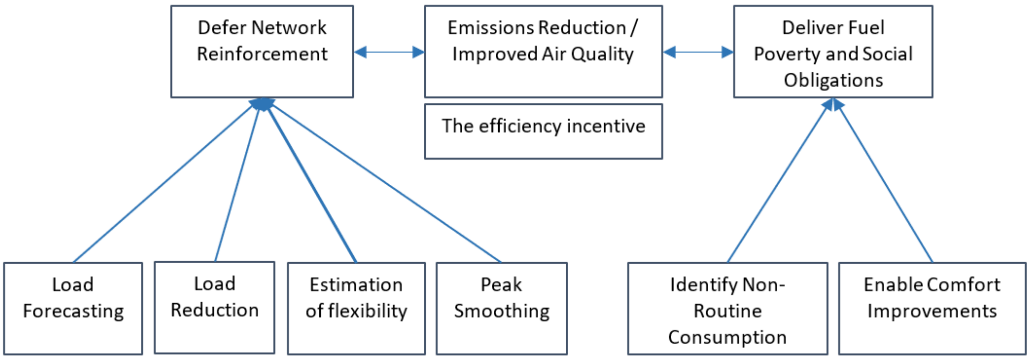
5.1.2 Short literature review on consumer attitudes to data sharing.

This literature review demonstrated how trust was a key consumer issue. As such, the RetroMeter Beta Phase Pilot scheme could make participants more comfortable with data sharing by:

- Emphasizing the clear benefit to participants from sharing their data, which will be highlighted in the form of higher accuracy in energy saving predictions for EE retrofits;
- Addressing the approaches taken to mitigate privacy concerns and security threats;
- Creating concise, simplified data sharing policies to increase participant understanding of who has access to their data and how it is handled.

5.1.3 Short literature review on value of residential energy efficiency to UK electricity system.

This literature review examined how measuring accurate energy savings from an energy efficiency (EE) retrofit project could be regarded as a grid resource, through the exploration of several value streams summarised in the diagram below:



EE measures can permanently increase power consumption, decrease power consumption, and can shift demand dynamically through smart meter data collection. These can lead to grid operators deferring network reinforcement, delivering their fuel poverty obligations, and phasing out old, polluting power plants commissioned for provision of capacity reserves.

This value of these projects is increased when the retrofits target high impact properties, with a particular focus on homes that are (or will be) electrically heated. The size of the home and the type of EE measure are secondary factors, with cavity wall insulation and solar PV having the most significant effect, but significantly less than the severity of network constraints. Geography of households matter too, as EE provides higher value to the grid in areas with a high population density and high deprivation, as network constraints tend to be a local phenomenon.

5.2 Householder Pay for Performance Demand

This deliverable sets out some of the key work done to date by Carbon Co-op on retrofit delivery. These previous projects show potential for ambitious retrofit schemes to be delivered. This ambition has several aspects - ranging from the scale of measures (in particular the notion of whole house retrofit, and not piecemeal or single measures), the centering of residents in design and delivery, area and neighbourhood-based approaches, and a focus on high quality works. This kind of local approach can offer a high degree of control around design, specification and installation - which brings benefits when it comes to evaluating whether intended outcomes are met.

5.2.1 Approaches to evaluation in the domestic retrofit sector

Within Carbon Co-op's work, and the retrofit sector more broadly, performance is being understood in more detail, with general trends of digitisation and an appreciation for the role of quality data. This interest in performance and data exists within the owner occupier and social housing sectors in particular – and there is a growing sense that we are moving away from bespoke and 'one off' evaluation exercises, with demand for approaches that are scalable and can be integrated with wider retrofit systems and processes.

There is also increasing consensus around some key metrics - such as Energy Use Intensity (EUI) that support evaluation approaches based on 'actual' and metered consumption. Such metrics not only support Measurement and Verification (M&V) at a 'point in time', but also assist comparisons within the housing stock, and support target setting that is aligned with 2050/decarbonisation trajectories.

5.2.2 Financial models and 'pay for performance'

All of the projects presented have a financing solution to them - from grants to loans and co-funding, demonstrating that there are a variety of financial solutions available, and the requirement in most cases to stack these. The evidence on 'payment for performance' is less clear, particularly at the level of the householder. Research demonstrates a variety of motivations for householders commissioning works, with financial motivations only one among many. Related to this, the potential to evaluate the impact of retrofit works is complex – if motivations vary then the data required to evidence the delivery of 'a successful retrofit' is equally complex. Quantifying metered energy savings is one aspect of this - and presents methodological challenges in a domestic setting.

There is a spectrum of 'pay for performance' - at the most basic level this involves payment for outcomes generated, and at the opposite end it involves contractual arrangements that are more complex. From a householder perspective, 'pay for performance' might simply equate to a 'cashback' bonus for those already doing retrofit. However, processes need to be simple and easy to navigate - because retrofit has many moving parts as it is. To make this work requires an appreciation and experience of service design and systems thinking. For a delivery provider, 'pay for performance' may form one aspect of finance stacking, but the risk of this needs to be manageable.

5.3 Review of precedent and relevant regulations

Work Package 3, Deliverable 3 conducted a study of precedent and relevant regulations including identifying regulations or price control elements relevant to metered energy savings and previous research conducted by DNOs.

A review of the DNO licence conditions and business plans for RIIO-ED2 has highlighted some obligations and commitments regarding energy efficiency such as:

- publish a statement of network development information which should include the flexibility services or energy efficiency services that the DNO reasonably expects to need across their network area each financial year.
- promote the uptake of measures to improve energy efficiency, where it can cost-effectively alleviate the need to reinforce the network. This may include procuring energy efficiency services, where it is economic and efficient to do so.

Additionally, in our business plan Electricity North West have committed to:

- use flexibility first and this has been extended to include the use of energy efficiency.
- promote energy efficiency widely to deliver sustained energy savings for customers.
- purchase energy efficiency instead of network assets.

This clearly shows the need for energy efficiency as a service. Techniques such as that being developed in RetroMeter will be vital in understanding the benefits this service can bring to DNOs.

A search of previous research by DNOS has resulted in a number of projects relating to the value of energy efficiency to both customers and networks. An overview of these projects is given in the published WP3 D3 and D4 report. The review highlighted that learning from the DEFENDER and CrowdFlex projects may be relevant for RetroMeter. The projects are currently active and an exchange of learning would reduce any possible duplication and lead to better outcomes for GB customers.

5.4 High level constraint management zones

Work Package 3, Deliverable 4 detailed the process to identify constraint management zones and the identification of specific candidate zones for energy efficiency investment in the Electricity North West region.

This section of the WP3 D3 and D4 report details the Electricity North West flexible tender process including; demand forecasting, tender creation, tender publication, criteria for participation, selection and baselining. This process produces the constraint management zones, with the most recent published as part of our 2023 spring tender which is seeking flexibility providers for 1097MW of flexibility in 32 locations across our region.

5.4.1 Baselining for Energy Efficiency Measures

Electricity North West have not yet received any flexibility tender responses which use energy efficiency measures but to enable the use of these measures it is envisaged that participants would need to provide historical metering data for the properties where they intend to deploy the energy efficiency measures. This data would be used to determine the historical baseline from which to measure the effectiveness of the energy efficiency measures.

Following the deployment of energy efficiency measures, it is likely that participants may decide to install additional electrical equipment which may mask the energy savings they have achieved through energy efficiency measures. Depending on the energy efficiency measure and the additional electrical equipment allowances may be made, for example:

- if insulation was installed to reduce heating demand and, at a later date, an electric vehicle was purchased the customer would still be eligible for the payments associated with the energy savings from the insulation installation. The energy used by the electric vehicle should be netted off the customers baseline, so it does not impact the customers income. Where this scenario occurs, the participant would need provide agreement in writing prior to installation.

- whereas if, following the deployment of the insulation to reduce heating demands, the customer installed additional electrical heating increasing their electrical heating demand on the network, no allowance will be given, and the customers income would be reduced.

All scenarios will be assessed on a case-by-case basis.

Elements of weather correction will need to be considered within the baseline where energy efficiency measures are related to building heating and cooling demands, however currently a methodology for this has not been created.

5.5 Scenario value estimates of proposed delivery options

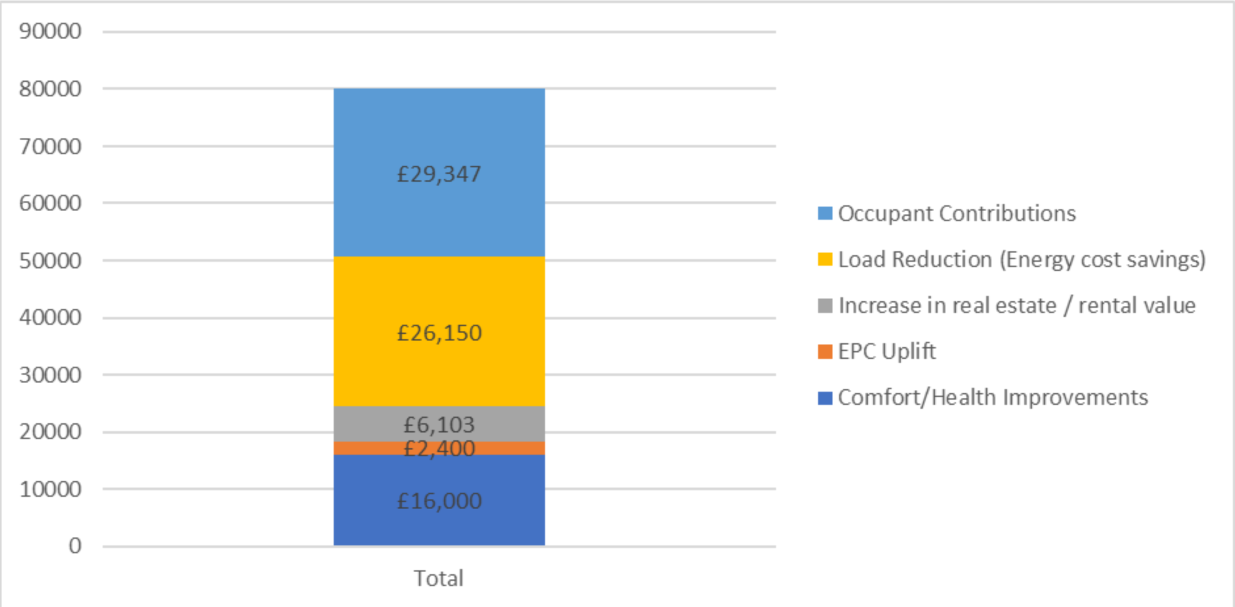
This section presented a number of scenario value estimates for an illustrative retrofit of a 2 bedroom maisonette in Oldham, Manchester. This illustrative retrofit would cost £80,000 (equivalent to the value of the home currently) but would bring the home as close as possible to net zero, saving 2.67 tCO_2e per annum or 100% of estimated emissions.

The retrofit in question was proposed by the "Your Home Better" tool used for planning retrofits across Manchester. A full list of scenario value estimates and assumptions can be found in the appendix of the Milestone 3.1 report, including variations of the two core models presented below.

In addition, supplementary calculations demonstrating possible values per kW of avoided capacity or home retrofit found values ranging from £14.18 - £40.32 per kVA of deferred capacity upgrades. When expressed as a per home cost (assuming 200 homes per substation), this value ranges from £22.34 - £151.41. This reinforces the need to "stack" disparate value streams as shown in the graphs below:

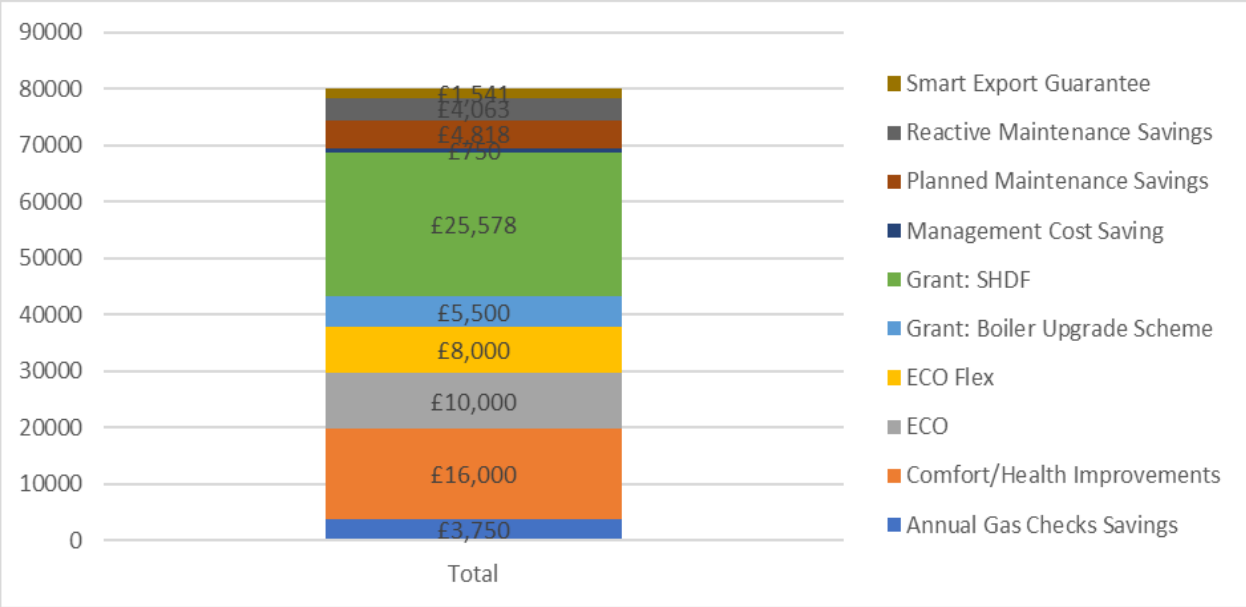
5.5.1 Area Based Scheme (core revenues only)

The values assigned to each revenue stream equate to a 25 project/asset lifespan, with all flexibility revenues being derived from 5 yearly payments for each year's heating season over a five-year span.



5.5.2 Metered Social Benefits (core revenues including SHDF)

The values assigned to each revenue stream equate to a 25 project/asset lifespan, with all flexibility revenues being derived from 5 yearly payments for each year's heating season over a five-year span.



5.5.3 Actions to carry forward from this deliverable

1. Determine if feasible implementations of the above value streams and scenarios will be available in the Alpha and Beta phases.
2. Compare the theoretical values generated in the upcoming section to real values as evaluated by Alpha and Beta phases.

5.6 Literature review on Pay for Performance (P4P) design

5.6.1 The significance of Pay for Performance design

The review of relevant literature identified the following barriers that are currently present within UK retrofit delivery approaches:

1. Large scale finance cannot be deployed where project performance and financial viability remains uncertain.

2. Engagement of residential consumers can be limited by a lack of trust and understanding, particularly where impacts are unquantified.

3. The value of retrofit is distributed across the energy system and often disparate.

However, this literature review also identified how pay-for-performance designs can help to address these barriers as:

1. Government may be willing to invest more money in publicly funded programmes (such as the Social Housing Decarbonisation Fund (SHDF)) and similar retrofit schemes if robust data on success & performance outcomes is available.

2. P4P provides ongoing approach in which energy performance, and therefore value to the consumer, is measured and verified can build ongoing dialogues and trust.

3. Measuring and verifying these distributed value streams through P4P allows an aggregator to draw them together into a comprehensive business model.

However, the barriers above are a subset of the larger issues the industry faces, and P4P is not a "silver bullet" for many of these barriers. As these barriers will likely impact any project the RetroMeter consortium pursues we should acknowledge that P4P itself is only part of a solution.

However, P4P design helps to improve the robustness of models, a key issue discussed in upcoming summaries. The flexibility and ability of different revenue streams to "compete" to underpin delivery models and realise their underlying value is a key advantage of P4P approaches compared to traditional alternatives, as the individual actors are all incentivised to provide accurate estimations of value and to realised this. This helps to spread risk across the various parties best positioned to mitigate the specific risk source. In this way, the P4P approach helps us to realise two of the components of a successful retrofit delivery model: sustainability (the ability to adapt and sustain itself into the future) and robustness (the ability to resist market shocks such as energy price inflation and sudden changes such as legislative advancements etc).

> A successful retrofit delivery model will be:
>
> **Sustainable, Robust, Equitable and Transparent.**

The emphasised note above also refers to two other components, equitability and transparency. Each of these can be examined in turn:

- P4P helps delivery models to be more **equitable** by ensuring that the risks are distributed with the parties best able to mitigate issues and deliver a successful energy improvement. For example, by ensuring the homeowner only pays for the performance they actually receive, it ensures that they will have sufficient avoided costs to cover repayments and ensures that less reputable contractors are not able to sell measures with low suitability for a specific home, as in this case they will receive no bonus and may receive a malus. By enabling public sector bodies or community led intermediaries to define the incentives and value rewarded, P4P can provide a delivery model which is more equitable than other market approaches.
- P4P helps delivery models to be more **transparent** by ensuring that the measurement of success is implicit in every project, where many other delivery models depend on deemed savings and sporadic ex-ante evaluations. By using real measurements and "metering" energy savings, the occupants/owners can review the real-world performance of their building before and after retrofit and ensure that it meets their expectations. These expectations will likely be complex, and so more markers of success may need to be considered beyond pure energy savings. Understanding these markets of success will help to overcome other challenged over

how the service is designed and communicated for residents. This is also the case at the regional and institutional scale, where aggregated performance outcomes can be gathered and iteratively reviewed to ensure the right measures are installed in the right contexts and that programme effectiveness is maximised. Whilst other schemes may include an element of measurement and verification, it is often poorly incentivised and funded, whilst P4P schemes ensure it plays a central role.

5.6.2 Actions to carry forward from this deliverable

1. Monitoring of advances to methodologies inside and outside of the RetroMeter should be explicit throughout Alpha and Beta phases, names CalTrack, SENSEIT and the heat pump ready programme.
2. The phase should target the market segments highlighted above but should also explore how the scheme could expand through various tenures and target markets, modelling diverse approaches to funding retrofit in various contexts
3. P4P evaluation metrics, large-scale databases and descriptions of qualified measures will need to be developed in the Alpha phase and beyond.
4. The Alpha and Beta phases present an ideal opportunities for calling for the development and standardisation of national objectives and policies to support retrofit, particularly around understanding uncertainty thresholds and how these will interact with the subsidy of performance risk.
5. The barriers identified by the Sensei project should form part of the evaluation of P4P pilots where they are likely to prevent upscaling of the delivery model.
6. Payment schedules and scheme design must be carefully considered and iteratively assessed to ensure that positive influences on the market result from any pilots or P4P programmes. The elements of scheme design should be explored further in the Alpha and Beta phases.

5.7 Manchester retrofit stakeholder mapping

This deliverable (Work Package 3, Deliverable 7) serves as a guide to understanding the complex ecosystem of stakeholders involved in the domestic, energy efficiency retrofit sector within Manchester. This report sets out to map and analyse the key stakeholders, their roles and their interrelationships as part of implementing a retrofit project in Manchester.

5.7.1 Section 1: retrofit stakeholders

The first section of this report provides an overview of a wide range of stakeholders, including potential public and private finance providers, stakeholders in the retrofit supply chain who may contribute to blockages, precedent studies and community outreach organisations in the local borough.

Necessarily, given the broad scope of domestic retrofit, the variety of tenures and archetypes and the variety of financing and delivery models available, this section is extremely broad in its scope. Likewise, many of the stakeholders operate not just at a local authority level but on a city regional, regional or national scale.

5.7.2 Section 2: Local Authority role in the potential Pay for Performance (P4P) demonstrator

The second section of this report is more specific, setting out the role of a local authority, Manchester City Council (MCC), in the delivery of a potential pay for performance demonstrator project to inform the development of a Metered Energy Savings methodology.

- Manchester City Council – Social Housing Decarbonisation Fund (SHDF) boiler replacement project

MCC successfully bid for SHDF w2.1 funding to install air source heat pumps on 1,000 of their properties and carry out required energy efficiency measures. The proposed measures include ASHP, external wall insulation (EWI), ventilation, low energy lighting and new heating controls, bringing the EPC rating of the properties from EPC D to EPC C. MCC also secured £50,000 of digitalisation funding (plus £50,000 of co-funding) with the anticipation of using this to install pre- and post-monitoring equipment on some of the properties. This offers significant potential to secure the data necessary for the beta phase project. Provided the MCC internal go-ahead is received for the scheme in late May/early June, MCC expects work on the properties to start in ~autumn 2023 and be concluded by September 2025. In particular, there will likely be an opportunity to undertake pre-installation monitoring in the colder months of winter 2023/24. An area for greater investigation at Alpha phase is the degree to which the location of the homes and the installation of air source heat pumps at scale might impact on the local network.

- A community intermediary, multi-tenure approach

Another delivery model is a multi-tenure, area-based retrofit scheme, operated by a community intermediary organisation. The intermediary aggregates finance, procures design and a contractor and acts as a conduit for stakeholders and other strategic partners. In Levenshulme, South Manchester, the current area-based scheme is being coordinated by Carbon Co-op with the involvement of Manchester City Council and others. The degree of control over design, procurement and installation, as well as the trusted relationship between community intermediary and householders, offers excellent potential for securing data and engagement to test a metered energy savings methodology.

5.8 Final delivery model

5.8.1 Elements of the final delivery model

An innovation curve was identified for developing P4P schemes in the UK and connected these to the work of the RetroMeter project. The value stacks that RetroMeter could unlock from both metered energy savings and DSR have been mapped onto specific tiers and actors of the UK market. From here 9 delivery model variations were identified and assessed based on accessibility, acceptability and applicability within the UK market. Two of these models were carried forward based on this analysis to be hypothesised in depth and have key relationships and revenue streams mapped. These are the area-based scheme and the metered social benefits concepts introduced in above summaries.

The financial and risk implications of these delivery models have been further evaluated and will continue to be discussed in upcoming work. In addition to the financial viability of each use case, upcoming work (likely in the beta phase), will seek to codify and critique the following components of a P4P scheme design:

- **Driving Factors**

    - **ESG objectives:** The environmental, social or governance goals that a scheme is trying to achieve.
    - **Regulatory drivers:** The legislation that motivates participation in the scheme or energy improvement activities more generally (i.e. MEES compliance in the UK)
- **<u>Core structure</u>**
    - **Core approach and incentives (reverse auction, fixed price, negotiated price etc):** How the expected level of project performance is established and paid for.
    - **Administrating Actor (utility, system operator, LA, public service org.):** The persons or institutions responsible for administrating the scheme.
    - **Actor Roles:** The various core and supporting roles played by UK actors.
    - **Funding source:** Where the funding for P4P projects or performance subsidies is derived from. This will interact with the level of risk that the public and delivery organisations are willing to take, and the uncertainty and error thresholds set by the P4P scheme.
    - **Target Customer Segment:** Who is receiving various P4P energy improvement measures and how they will be segmented and targeted.
    - **Eligible Measures:** The various energy improvement measures which can be delivered reliably through a P4P scheme.
- **<u>Performance assessment Methods</u>**
    - **Assessment protocol:** How will performance be determined?
    - **Baseline requirements and data eligibility:** What requirements will be in place to adequately determine performance.
    - **Metering Technology:** How will measurements be taken and captured at scale?
    - **Control and comparison groups; Segmentation methodologies**: How energy performance measurements will be compared within cohorts or adjusted in line with control groups.
- **<u>Payment structure and schedules</u>**
    - **Beneficiary**: The party which receives the performance-related payment.
    - **Risk-bearers:** The party which bears some or all of the performance risk. This is not always identical to the beneficiary.
    - **Contract duration:** How long performance will be measured for and performance-related payments made.
    - **Reward Structure:** How will beneficial payments be made to motivate project performance?
    - **Unit Price:** What price is acceptable and feasible for the improvement of various indicators or "valuable units" such as kWh saved, kWh/m2 of energy intensity reduced etc.
- **<u>Supporting Factors:</u>** These are outlined above but include development of standardised indicators, uncertainty thresholds, requirements for governance procedures or stakeholder engagement etc.

An assessment of value stack risks and mitigation strategies was also conducted for all revenue streams considered for the final delivery model, finding that of the 24 revenue streams proposed, only half are low risk, with a further 10 having "medium" risk ratings, and 2 having "High" risk ratings, mainly around the capture of externalities that cross regional boundaries.

5.8.2 Actions to carry forward from this deliverable

1. Finalise deliver models and their variants that cover the full innovation curve.
2. Review the "significance" ratings above and risk registers in the upcoming section to improve the robustness of pilots throughout and beyond the Alpha and Beta phases