# RetroMeter:

## Review of Delivery Model Options for the deployment of metered energy savings methods in the United Kingdom

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# Contents

# Introduction

This report ties together 4 deliverables from the Discovery Phase of the RetroMeter Strategic Innovation Fund project funded by Ofgem. This work was initially completed by ep consulting (Scenario value estimates, P4P literature review and delivery model options appraisal) and Carbon Coop (Manchester retrofit stakeholder mapping report), but additional input has been provided by Electricity North West Limited and the Energy Systems Catapult.

This report will walk through existing designs on the market, the stakeholders needed to replicate these in Manchester (for the Alpha and Beta pilots) and the components and revenue streams required to assess and deliver hypothesised delivery models. Each section concludes with actions and insight to be carried forward for further work and the final section will describe the quantified value of each delivery model assessed.

# Literature Review: Pay-for-Performance (P4P) programme design

## Problem Background:

The validation and improvement of metered energy savings methods requires engagement from a large number of industry actors and members of the public. A business model is needed to motivate this and to help deliver the necessary improvements to domestic buildings. Pay for performance (P4P) models have been touted as an appropriate business model for underpinning these large-scale retrofits. However, these pay for performance models are unproven in the UK due to the small number and scale of P4P trials to date.

## Problem Statement:

Building upon the context described above, we can define multiple problem statements to investigate throughout the course of this literature, as numbered below:

1. Are pay for performance models successfully delivering and financing energy improvements across the globe, and in what contexts?
2. Could pay for performance models be applied in a similar manner in the UK to achieve success?

## Objectives of Literature Review:

The problem statements above posit two key questions for this report, which will need to be addressed in turn in order to guide the work of this report. These have been converted into specific objectives below, each concerning itself with one of the two key interactions of a P4P model: what market conditions need to be in place for performance-based financing?; and what methodologies are suitable for capitalising on these market conditions to ensure

successful delivery of high-quality retrofit projects?. These concerns will be investigated through the lens of the two objectives below, where we aim to:

1. Identify one or more successful P4P models around the globe and identify the characteristics that underpinned this success.
2. Identify one or more methodologies (and related conditions) that would need to be in place for these P4P models to succeed in the UK.

## Key sources:

A full evaluation of key sources can be found in the Appendix. Sources varied from assessment of specific schemes and market impacts through to ex-ante evaluation of multiple P4P programmes. The majority of sources refer to US commercial/industrial contexts, save for the Pacific Gas & Electric (PG&E) residential P4P pilot. The primary source for European innovation on P4P models was the SENSEI programme, which will be key for this work moving forward.

## What each Source states for the problem statement?

This section summarises the key insights gathered for each problem statement from the full range of sources investigated (see Appendix). This section directly feeds into the summary of recommendations and actions/insights to be carried forward for further work.

***Identify one or more successful P4P models around the globe and identify the characteristics that underpinned this success.***

- Although validation and piloting is needed SENSEI proposed specific characteristics which would support successful P4P schemes across Europe:
    - Policy measures such as ensuring involvement of broader stakeholders, public estates and Small to Medium Enterprises (SME)s.
    - Evaluate and measure energy savings for broad technologies and energy improvement measures to produce a "Catalogue of Quantified and Qualified Measures" which the methodology can accurately assess and embed in aggregation criteria.
    - Delivering and aggregating residential projects will require tools such as standardised indicators to streamline the evaluation and planning of energy efficiency measures, particularly for new customer segments. SENSEI has defined many of these already (Grillone, 2022).
    - Clear environmental/social objectives are needed to realise the full "value stack" of P4P delivery of energy improvements. These should be developed by government or public stakeholders and engrained in incentive structures and governance models.
    - A preliminary mapping and evaluation of contractual, fiscal, cultural and economic barriers will support deployment of P4P schemes, but iterative assessments should also be conducted. The governance models of these scheme must be responsive to these barriers and consumer expectations.
- Although the Heat Pump Ready Programme will not release final outputs until 2025, the RetroMeter consortium should consider engaging some project partners from these trials to gain early insight and access to data, particularly those operating in social housing and non-traditional buildings.

- CalTrack's OpenEEMeter is not currently sufficiently calibrated to support a UK P4P programme involving either household- or portfolio-level calculation of metered energy savings, primarily due to issues modelling gas consumption. UK-specific error and uncertainty thresholds will be key to develop a functioning P4P market.
- PG&E's residential P4P pilots ran from 2018-2022 (possibly ongoing, but no reference found), achieving some success in the US in portfolios of residential homes. This system used CalTrack methods on aggregated portfolios with large amounts of data. Almost all other successful P4P programmes run in non-domestic sectors, with all but one identified operating within the US.

***Identify one or more methodologies (and related conditions) that would need to be in place for these P4P models to succeed in the UK.***

- SENSEI provides key methods for quantifying and monetising the benefits of P4P schemes (Bourgois et al., 2021), and methods for ex-ante evaluation based on these multiple benefits:
    - energy cost savings,
    - employee productivity increase due to increased comfort
    - increased building value,
    - optimized operation and maintenance costs,
    - avoided costs for the power system.
- Access to a range of control groups, contextual information and energy consumption data such as those being developed through the Heat Pump Ready Programme will be a key supporting condition for the successful deployment/evaluation of UK P4P methods.
- The OpenEEMeter method will be a key starting point for UK P4P schemes, due to its strong intra-day modelling of electricity usage. However, there is evidence that OpenEEMeter has been superceded by more recent approaches to modelling DSR
    - Regardless of methodology, resolving double-penalty effects may be required for household-level DSR solutions to be appropriate.
- The OpenEEMeter hourly model fell marginally below test-period P4P compliance for electricity data, and with appropriate adjustments could support a portfolio-level P4P programme in the UK.
    - Access to large scale gas data will be needed to validate OpenEEMeter's use on portfolio level programmes.
- Permanent Non-routine Events (NREs) such as those introduced by COVID-19 may need to be adjusted for using control and comparison groups, as detailed by PG&Es Normalised Metered Energy Consumption (NMEC) evaluation (Demand Side Analytics, 2021). These adjustments will unlock historic data spanning the pandemic period (2019-ongoing). The fossil fuel price crisis caused by the invasion of Ukraine is another key example of a long-term NRE.
    - Control groups generally improve model accuracy, particularly when matched with specific segmentation approaches.
    - Divulgence of individual non-participant data can be avoided through use of granular profiles instead of individual-matched control groups, with comparable results. Development of these granular profiles would strongly support delivery of P4P schemes, particularly within a specific region or residential market segment.
- Any data that assists with the disaggregation of heat and building states may be key for supplementing existing methods, in particular assumptions of diurnal heating patterns, disaggregated energy consumption for heating end uses or use of additional methods such as gradient boosting machine which identifies changing building states (such as warm-up periods when boiler programmes activate in the morning).
- Standardised national policies should be considered and put in place, in particular regarding error and uncertainty thresholds and how these will interact with the subsidy of

performance risk. The work conducted by James Fenna and the Lawrence Berkeley National Laboratory's M&V2.0 team can assist with this policy development.
- The provision of "assumed open" smart meter (or high-granularity) data would accelerate this work hugely, along with key data sufficiency tests and eligibility criteria to swiftly form and standardised portfolios of homes to be modelled.
- An assessment of energy savings for broad technology types would unlock a "Catalogue of Quantified and Qualified Measures" which the methodology can accurately assess and embed in aggregation criteria. This assessment should take a cautious view on deemed estimations to ensure that overestimation issues with deemed savings are not carried through to pilots. This will be key for specific or novel technologies such as heat pump installations, which may diverge significantly from savings estimates based on occupant behaviour and climatic conditions.
- Payment schedules and scheme design must be carefully assessed to ensure that positive influences on the market result from any pilots or P4P programmes. The design of schemes will be explored more in the upcoming section.

## How this will affect our work:

The key learnings summarised above will be drawn into the work of the RetroMeter project in a number of ways, listed below.

1) Identification of underpinning methods to be tested further.
2) Determination of use cases and delivery models for further investigation (based on underpinning methods)
3) Identification of prerequisite supporting conditions for viable use cases. These will assembled as part of the above investigation, at which point they can be assessed by the consortium's level of influence and scheduled alongside other development timelines.
4) Identification for evaluation approaches for delivery models. This will show how we will measure success of any P4P schemes proposed.
5) Production of recommendations for the improvement / reiteration of P4P scheme design in the UK. This will include a mapping of the components of these schemes in order to hypothesise a UK-specialised delivery model for energy efficiency based on metered energy savings calculation methods.

The impact of these learnings on the consortium's upcoming work is described below for each topic in turn.

### *Identification of underpinning methods to be tested further.*

- The CalTrack methods (OpenEEMeter) are the closest to complying with American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) Guidelines for modelling UK contexts and so investigations into further refinements should be conducted. Approaches similar to CalTrack such as the SENSEI EEnsight package should not be discounted, particularly where prior research by this consortium showed equivalent or marginally better performance (Energy Systems Catapult & ep group, 2022).
    - The extension of the CalTrack methods through the OpenEnEffs project (Carbon Coop, 2023) should be investigated further as part of this research.
- The Heat Pump Ready Programme should be monitored for any novel methodologies for metering fuel switches and efficiency gains arising from heating system changes.

### *Determination of use cases and delivery models for further investigation (based on underpinning methods)*

- Both metered energy savings and demand side response use cases could drive P4P schemes in the UK residential market.
- The following market segments are being assessed by UK innovation programmes, and should be investigated further as part of the RetroMeter engagement:
    - Social Housing Retrofit;
    - Local Residential Retrofit (by building typology or measure) through Community Energy Groups;
    - Retrofit of Non-traditional Residential Buildings (i.e. Permitted Developments that converted offices into residential units).
- Although the RetroMeter consortium is focused on the residential sector, learnings from the wastewater sector could reveal interesting delivery models, such as the Asset Management Plan Period used to define framework durations, key performance indicators and price / incentive reviews. Standardised savings estimations are conducted to determine the best investments and savings potentials. A reverse auction approach could be considered for residential retrofit contractors.
- A "Stacked" approach will likely be key for unlocking P4P schemes in the UK, with all key actors from Aggregators to ESCOs, Economic Agents, the Public Authority, the System Operator, the Fund and the Private Third Party Investors integrated. The aggregator sits centrally and assures outcomes in return for fixed remuneration from the public authority in the model proposed by SENSEI. More research will be needed to determine the exact value stream for each actor.

### *Identification of prerequisite supporting conditions for viable use cases.*

- P4P evaluation metrics from the SENSEI project should be integrated and where needed adapted to UK contexts.
- Large scale datasets should be made available, including access to a range of control groups, contextual information and energy consumption data such as those being developed through the Heat Pump Ready Programme. The provision of large scale gas datasets will be key to unlock metered savings for heating interventions.
- Double-penalty effects may need to be resolved prior to the deployment of P4P household-level DSR use cases.
- Control groups should be made available, as they not only generally improve model accuracy, but also enable adjustment for permanent NREs such as those introduced by the invasion of Ukraine or the COVID-19 pandemic, as detailed by PG&Es NMEC evaluation (Demand Side Analytics, 2021).
    - Divulgence of individual non-participant data can be avoided through use of granular profiles instead of individual-matched control groups, with comparable results. Development of these granular profiles would strongly support delivery of P4P schemes, particularly within a specific region or residential market segment.
- National policies need development and standardisation, in particular regarding error and uncertainty thresholds and how these will interact with the subsidy of performance risk.
- A "Catalogue of Quantified and Qualified Measures" which the methodology can accurately assess and embed in aggregation criteria should be investigated and produced.

### *Identification for evaluation approaches for delivery models.*

- Sensei provides a preliminary mapping and evaluation of contractual, fiscal, cultural and economic barriers that need to be addressed to support deployment of P4P schemes, but iterative assessments should also be conducted as P4P schemes mature. These barriers should form part of the evaluation of P4P pilots where they are likely to prevent upscaling of the delivery model.
- SENSEI provides key methods for quantifying and monetising the benefits of P4P schemes (Bourgois et al., 2021), and methods for ex-ante evaluation based on the five multiple benefits listed above:
- The evaluation of delivery models should consider allowable error and uncertainty thresholds for each method to determine how performance risk is distributed in the final scheme design.
- An assessment of modelling uncertainty across broad technology types would assist with developing a "Catalogue of Quantified and Qualified Measures" for each methodology under evaluation, which may allow different methods to be deployed depending on depth and design of retrofit offers.

### *Production of recommendations for the improvement / reiteration of P4P scheme design in the UK.*

- The UK government will need to roll out a range of policy measures to support deployment of UK P4P schemes such as ensuring involvement of broader stakeholders, public estates and SMEs. In addition, UK-specific error and uncertainty thresholds will be key to develop a functioning P4P market. Standardised indicators and other assessment tools will assist with delivering and aggregating residential projects at speed and scale, particularly for new customer segments.
- UK Government or public stakeholders should develop clear environmental/social objectives to realise the full "value stack" of P4P delivery and embed these in incentive structures and governance models.
- Any P4P findings from the Heat Pump Ready Programme should be monitored and integrated, particularly those operating in social housing and non-traditional buildings, or where open data is available.
- Availability of control groups, contextual information and energy consumption data such as those being developed through the Heat Pump Ready Programme (Department for Energy Security and Net Zero, 2023) will be a key condition supporting UK P4P methods.
- Making key data available to assist with the disaggregation of heat and building states will be key for adapting and supplementing existing methods for UK contexts.
- 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 are explored more overleaf.

## Actions to carry forward to further work and the Alpha Phase

Now that we have engaged the current approaches to P4P available on global markets, we can begin to summarise the actions and outcomes to be carried forward into further work and the Alpha Phase. Following these recommendations, the upcoming section (Manchester retrofit stakeholder mapping) will seek to understand the actors and stakeholder's whose engagement will help to realise this further work and insight.

1. Monitoring of advances to methodologies inside and outside of the RetroMeter should be explicit throughout Alpha and Beta phases, names CalTrack, SENSEI 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.

# Manchester Retrofit Stakeholder Mapping

## Introduction

This report 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.

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.

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.

## Section 1 - Retrofit Stakeholders

### *2. Potential Finance Providers*

This section sets out potential finance providers for a project based in Manchester, encompassing both public sector grants and private sector green financing. The following providers offer a mix of grants, loans and investments aimed at supporting retrofit projects and energy efficiency improvements:

#### ***2.1 Public Sector Funding***

- **Social Housing Decarbonisation Fund (SHDF) - Government funding:** GMCA has received £37 million of funding for wave 2.1 of the SHDF programme for social housing retrofit across Greater Manchester, Manchester City Council has received £11m of this, with further funding provided to other social landlords in the city. SHDF-funding will enable the retrofit of approximately 3,000 social homes in the city by September 2025.
  https://www.manchester.gov.uk/news/article/9251/20m_secured_by_manchester_city_council_for_energy_efficiency_retrofits
- **Home Upgrade Grant (HUG):** HUG is a funding program that has been awarded to selected Local Authorities across England. Manchester City Council has received £10.4 million from phase 2 of the HUG programme to offer energy efficiency upgrades and low carbon heating to eligible households that are low income, off the gas grid, and have an Energy Performance Certificate (EPC) rating between D and

G. HUG2 funding is expected to result in the retrofit of approximately 500 homes by March 2025.

- **Manchester City Council through the Housing Revenue Account (HRA)**: MCC's internal Housing Revenue Account (HRA) is a separate account ring-fenced for housing-related purposes. Income comes from various sources, primarily from Council tenants' rents. It is generally used to cover the cost of managing, maintaining, repairing, and improving council housing stock. Manchester City Council's HRA could be used to fund retrofit projects in Council-owned properties; however, using HRA funds for retrofit projects would depend on the council's priorities, budgetary constraints, and available funds within the HRA.
- **ECO**: The Energy Company Obligation (ECO) is a Government energy efficiency scheme in Great Britain designed to tackle fuel poverty and help reduce carbon emissions. The scheme has seen 4 iterations, ECO, ECO1, ECO2 and ECO3. The ECO4 Order came into force in July 2022. ECO4 applies to measures installed from 1 April 2022 and will cover a four-year period until 31 March 2026. Local authorities have the ability to target vulnerable households that may not qualify for the funding on the grounds of receiving benefits only. Manchester is expecting to see up to 1,200 homes retrofitted through this ECO4 flexibility programme by March 2026.

### ***2.2 Private sector green financing loans and investments***

A variety of finance intermediaries offer financing for retrofit projects and programmes across tenures and scales. However, it should be noted that numerous policy review documents [for example, the Green Finance Institute, 2020], have set out the limitations of such funding in scope and scale. This has led to Government innovation programmes such as the Green Homes Finance Accelerator [https://programmes.carbontrust.com/ghfa/] (Carbon Co-op is a Measurement & Verification (M&V) partner on one of the North West projects). The Green Finance Initiative (GFI) also has an 18 months long project in Greater Manchester to support the development of finance for retrofit in the city region and will be involved in brokering discussions with banks and lenders and expanding the market intelligence on owner occupier clients in the area. The list of relevant funders is provided below:

Ethical/community lenders:

- **Nationwide Building Society** discounted loans For Green Home Improvements (announced May 2023).
- **Triodos Bank:** 'Ethical bank' offering financing for sustainable projects, including retrofitting and energy efficiency.
- **Ecology Building Society**: Provides renovation mortgages for single dwelling renovations to improve their energy efficiency.
- **Manchester Credit Union:** Is currently offering loans to homeowners in Manchester through Your Home Better to install solar panels and battery storage.

Private lenders:

- **Lloyds Banking Group:** Offers green financing loans or investment that supports environmentally-friendly activity, including improving energy efficiency in homes.

Investment platforms:

- **Abundance Investment:** This is an investment platform that allows people to invest in green projects, including energy efficiency and retrofit schemes.
- **M&G Investments:** Offers green bonds and other sustainable investment options.
- **LendInvest's Green Bond Framework**: This framework is designed to accelerate the allocation of capital to eligible retrofit projects in the UK to decarbonise the UK's housing stock in the form of green loans to borrowers.

Advocates/support organisations:

- **Bankers Without Boundaries** - an innovator in finance, is a not-for-profit powered by former investment bankers to assist high impact projects that benefit the environment and social good.
- **3Ci** is a partnership between Connected Places Catapult, Core Cities UK, London Councils and other local authorities across the UK aimed at supporting local authorities secure the necessary long-term finance for achieving net zero.
- **Green Finance Initiative (GFI)** - established in 2019 as a direct response to a key policy recommendation made by the industry-led Green Finance Taskforce to the UK Government in March 2018.

## *3. Supply Chain Blockages*

There are well documented supply chain blockages impacting on retrofit delivery, in terms of the scope and scale of what can be delivered and also the final quality of work. This section lists out the various stakeholders that contribute to the resolution of supply chain blockages in Manchester's retrofit sector:

### *3.1 Manufacturers*

Manufacturers who produce retrofit components i.e windows, insulation, HVAC systems, solar panels, heat pumps, controls and monitoring equipment etc. may face production delays, shortages of raw materials or labour issues.

### *3.2 Suppliers and distributors*

Suppliers and distributors who are responsible for sourcing and delivering the retrofit components from manufacturers to contractors can sometimes experience logistical challenges, transportation delays or inventory management issues that contribute to supply chain blockages.

### *3.3 Training providers*

Training providers play a critical role in the sector by equipping professionals with the skills, knowledge and qualifications needed to effectively implement retrofit works. By training people with retrofit skills across Manchester, these providers help to mitigate the risk of a shortage of skilled workers within the retrofit supply chain. Some of the training providers operating in Manchester include:

- **Greater Manchester colleges**: Manchester College, Oldham College, Trafford College etc etc (minimal specific retrofit training at present)
- **Low Carbon Academy**: https://www.lowcarbonacademy.co.uk; the Retrofit training arm of North West Skills Academy, delivering training services tendered by GMCA.
- **Procure Plus** - a local housing provider framework offering training delivery in line with social value obligations associated with public procurement.
- **Green Skills Academy** in Trafford Park run by the Greater Manchester Growth Hub https://www.gceducationandskills.ac.uk/green-skills-academy
- **B4Box** - a unique social enterprise combining contracting and training provision.
- **People Powered Retrofit** - offer supply chain development, training and CPD, focussing on the Refurbishment, Maintenance and Improvement sector.
- **Retrofit Academy CIC** - a national organisation that operates in partnership with others in the local area.

Both Greater Manchester and Manchester City Council learning and skills teams are developing approaches to tackling supply chain issues in the area. Manchester City Council are fairly well advanced with this and have good networks in place, with training providers able to act quickly as decisions are made about funding/use of certain technologies.

### ***3.4 Retrofit One Stop Shops (ROSS)***

Retrofit One Stop Shops (ROSS) are designed to streamline the retrofit process by providing a comprehensive range of services, including consultation, assessment, design, financing, installation and project management. Local Retrofit One Stop Shops operating locally, include:

- People Powered Retrofit
- Your Home Better (RetrofitWorks)
- Evergreen - heat pumps specialist

It is worth noting that there are different models of One Stop Shops. A report by Energy Cities and Innovate partners (2020) categorises these into the following types:

- **Facilitation model:** raise awareness on energy renovation benefits, provide general information on optimal renovation works, first advice at the 'orientation stage.'
- **Coordination model:** coordinate existing market actors (suppliers), make sure all one-stop-shop services are offered to homeowners, no responsibility for the result of renovation works (only overlooking the whole process), no responsibility for the overall customer journey (just the first part).
- **All-inclusive model:** offer a full renovation package to homeowners, bear responsibility for the result of renovation works, bear responsibility for the overall customer journey.
- **ESCO type model:** offer a full renovation package with guaranteed energy savings to homeowners, bear responsibility for the result of renovation works, bear responsibility for the overall customer journey.

## ***3.5 Home/building owners and property managers***

Those who initiate the retrofit projects may face budget finance constraints or regulatory constraints that may slow down the initiation or progress of a project. These could be housing associations, ALMOs (Arm's Length Management Organisation – a not for profit organisation that provides housing or housing services) or individual home or property/business owners/managers, for example:

- Great Places Housing Group
- Mosscare St. Vincents Housing Group
- One Manchester
- Southway Housing Trust
- Irwell Valley Homes
- Onward Homes
- Jigsaw Homes Group
- Regenda Homes
- Trafford Housing Trust
- Wythenshawe Community Housing Group
- ForViva Group
- Salix Homes
- Your Housing Group

Support organisations:

- **Northern Housing Consortium** (NHC) - a membership organisation representing over 400 local authorities, ALMOs and associations that provide social housing for tenants across the North of England. NHC has run a series of support projects focussed on retrofit.

## ***3.6 Retrofit Designers - Architects and engineers***

Architects and engineers play a critical role in the retrofit supply chain, contributing their expertise around design, planning and structural analysis together with providing technical retrofit solutions. Those playing a crucial role in the PAS2035 quality standard include:

- People Powered Retrofit (PPR): A Manchester-based organisation that provide home retrofitting design services.
- Ecospheric: a UK-based company offering retrofit consultancy and sustainable building solutions.

## ***3.7 Consultants***

- **Turner Townsend**: They are a consultancy practice that act as advisors providing public programme, cost, procurement and contract and risk management services. They have helped to support programmes such as SHDF (Social Housing Decarbonisation Fund) and the Home Upgrade Grant (HUG) through providing the Social Housing Retrofit Accelerator and Home Upgrade Hub.

- **Arup:** They are a consultancy practice that provide engineering, design and planning and sustainability consultancy.

### ***3.8 Tier One Contractors and/or Managing Agents***

Firms that are responsible for delivering retrofit projects may face labour shortages, limited access to equipment or difficulty acquiring permits to work.

- **Equans:** An international service provider focusing on energy, digital, and industrial solutions. They have experience in retrofit projects across the country and in 2021 signed a three-year contract with Manchester City Council to provide repair and maintenance services to over 13,000 council-owned homes in the City.
- **Casey:** have an existing relationship with Manchester City Council, span construction, civil engineering, land reclamation, public realm and environmental works, developments, and plant hire and service
- **Kier Group:** A leading UK construction company, involved in retrofit projects across Greater Manchester, offering expertise in energy-efficient building solutions and refurbishment of residential and commercial properties.
- **Willmott Dixon**: A renowned UK construction company specialising in sustainable building and refurbishment. Willmott Dixon has completed multiple retrofit projects including work with Hull City Council for 3,000 homes.
- **Wates Group:** A UK-based construction company, they completed a housing retrofit project for Northampton Partnership Homes and several housing retrofit projects in Stevenage and London Borough of Enfield.
- **Melius Homes:** A contractor specialising in energy efficient building solutions that partnered with Nottingham City Homes to deliver the energiesprong approach (a Dutch developed system of mass scale retrofit) to retrofitting homes in the Sneinton neighbourhood in 2018.

### ***3.9 Sectoral organisations***

- UK Green Building Council (have a local authority specific network for sharing information relating to retrofit)
- Innovate UK – Government funder for innovation in the sector
- Energy Systems Catapult - an independent, not-for-profit centre of excellence on Net Zero
- LETI – a network of over 1,000 built environment professionals, who publish guidance on how the sector can respond to the climate emergency (e.g. the Climate Emergency Retrofit Guide, 2021).
- Good Homes Alliance – a membership organisation covering themes across new build and retrofit, with specific networks for local authorities and housing associations.

## *4. Precedent Studies*

**Greater Manchester Retrofit Task Force** - Launched in July, 2021, the Greater Manchester Retrofit Task Force is a three-year programme aimed at addressing the climate crisis through innovative finance solutions and building the supply and demand for skills and jobs required for the retrofit supply chain. The taskforce is focussing on decarbonising heating, improving energy efficiency and reducing carbon emissions in homes and public buildings. These activities are summarised at the following links:

- An overview of the Retrofit campaign via GM Green City: https://gmgreencity.com/projects-and-campaigns/retrofit/
- Manchester City Council retrofit commitments: https://www.manchester.gov.uk/news/article/9102/manchester_to_tackle_low_carbon_housing_retrofit_challenge
- Greater Manchester Combined Authority (GMCA) RetrofitGM Action Plan: https://www.greatermanchester-ca.gov.uk/media/6018/retrofitgm.pdf
- Greater Manchester Combined Authority Retrofit Taskforce context: https://www.greatermanchester-ca.gov.uk/what-we-do/environment/homes-workplaces-and-public-buildings/retrofitgm/

## *5. Outreach Organisations*

This section lists out the various outreach organisations in Manchester that could be potentially involved at a variety of stages in a retrofit project in Manchester:

### *5.1 Community and Voluntary Sector*

- Manchester Community Central (Macc)
- Greater Manchester Centre for Voluntary Organisation (GMCVO)
- Citizen Advice Manchester
- End Fuel Poverty Coalition
- Manchester Social Economy Alliance
- Groundwork Greater Manchester

### *5.2 Community Energy organisations*

- Carbon Co-op (project partner) - with experience in piloting innovative retrofit schemes, particularly with owner occupier households (for example, Community Green Deal and the Levenshulme Area Based Scheme – as detailed in WP3 D4, householder demand assessment report).
- Greater Manchester Community Renewables (GMCR)
- And a host of small voluntary and community organisations who have initiated renewable energy schemes eg Saddleworth Hydro, New Mills Hydro etc.
    - These can be located via the Community Energy England project map: https://communityenergyengland.org/pages/nationalmap

### *5.3 Think Tanks*

- Centre for Local Economic Studies (CLES) - a Manchester-based think tank focussed on advocating for Community Wealth Building approaches.
- Ashden - with a particular focus on supply chain training.
- Green Alliance - sectoral intelligence
- New Economics Foundation - run the Great Homes Upgrade campaign.

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

### *1. Introduction*

This section sets out two potential delivery mechanisms for a beta phase, Metered Energy Savings demonstrator to assess potential pay for performance models.

Each involves different stakeholders operating in different ways, producing projects that operate at different scales. Each provides advantages and disadvantages with regards to the overall aims of the beta phase project and these are set out in greater detail in the section titled "*Hypothesised delivery models for energy efficiency based on Metered Energy Savings*".

### *2. Manchester City Council – Social Housing Decarbonisation Fund (SHDF) boiler replacement project:*

Manchester City Council owns a large number of terraced and semi-detached properties where the gas boilers are 15 years or older and nearing the end of their useful life. The properties are currently reported to have cavity wall insulation, but based on some archetype-level surveys MCC believes that in many instances this is either missing or has failed.

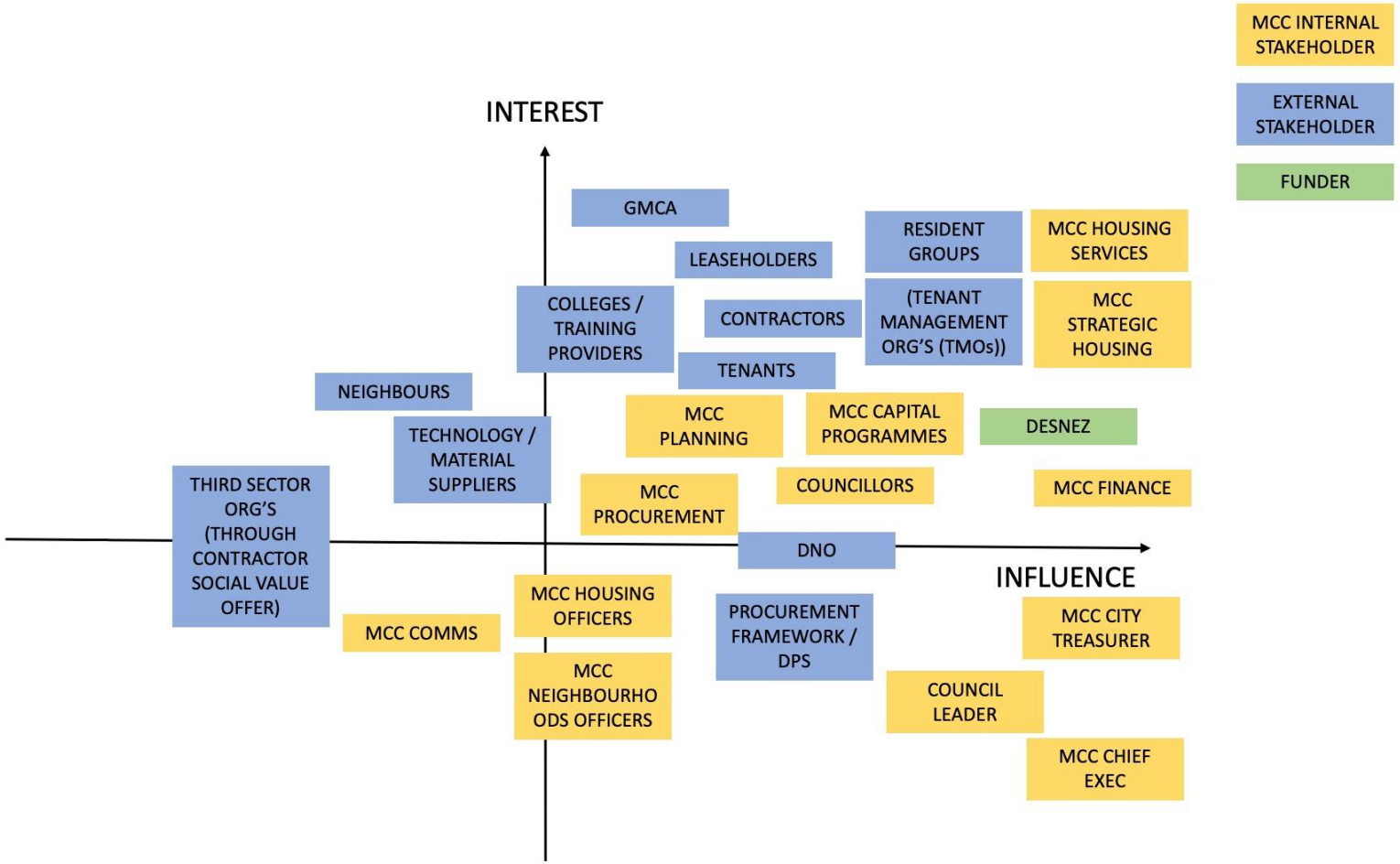
MCC successfully bid for SHDF w2.1 funding to install air source heat pumps on 1,000 of these properties and carry out required energy efficiency measures. The proposed measures on these properties include ASHP, external wall insulation (EWI), ventilation, low energy lighting and new heating controls, bringing the EPC rating of the properties from EPC D to EPC C (EPC C is the maximum 'allowed' under SHDF rules).

Separately from this, 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.

*SHDF Project Stakeholders map*



## *Stakeholder breakdown*

### MCC Internal stakeholders

### External stakeholders

- **Third Sector organisations** – for example those that the Council and its contractors will work with as part of social value activities. MCC work with a network of organisations through the North Manchester Social Value Framework. This allows us to put contractors in touch with appropriate organisations to maximise their social value impact during the SHDF project.
- **Neighbours** – those individuals and properties that are indirectly affected by the SHDF project
- Technology/material suppliers

Training providers

- Colleges

Combined authority

- GMCA, as the consortium lead for SHDF delivery. GMCA is helping the consortium by engaging with the DNO and training providers on the housing providers' behalf, investigating group procurement options, etc.

Contractors

- Turn-key contractors
- Specialist skills (e.g. fire safety, high rise, conservation area works)

Housing providers

- Other registered providers with SHDF projects in Greater Manchester, in order to share knowledge

Householders

- Leaseholders in tower blocks with planned SHDF works
- Tenants

Funders

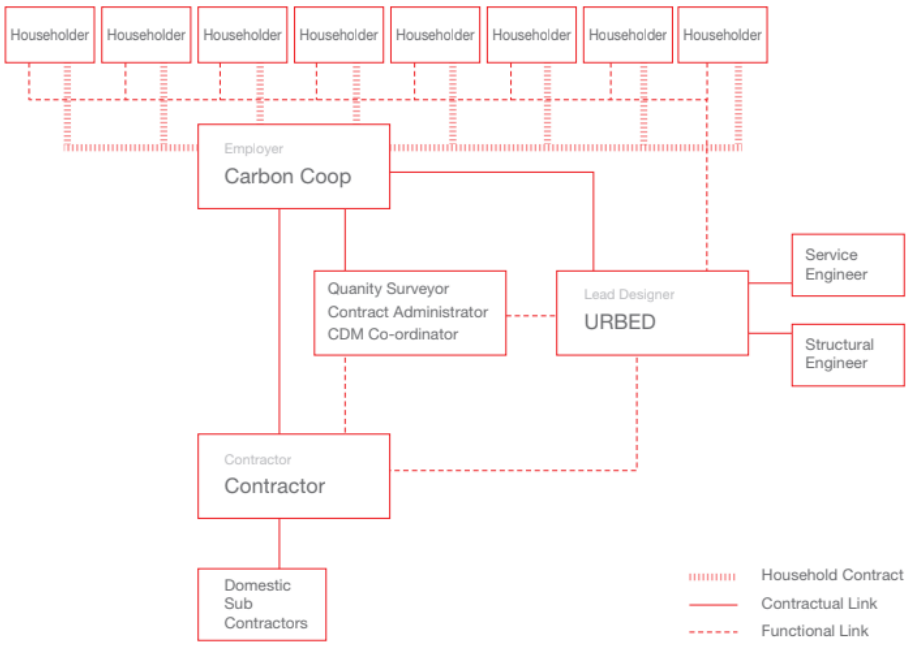
- Department for Energy Security and Net Zero (DESNZ) - Social Housing Decarbonisation Fund (SHDF)

## *3. A community intermediary, multi-tenure approach*

An alternative 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.

### Contracting model




The above figure is an example of the contractual arrangements between partners on a precursor scheme. This model enables Carbon Co-op to bulk procure the works as client intermediary.

## *Stakeholder breakdown*

### Carbon Co-op Internal stakeholders

- Carbon Co-op Leadership team: Retrofit, Energy Systems and Energy Commons Lead + Operations Lead
- Carbon Co-op board
- Carbon Co-op membership

### External stakeholders

- Third Sector organisations
- Neighbours
- Technology/material suppliers
- MCC Planning

**Training providers/Contractors**

- B4Box

**Designers**

- Progress in Practice
- People Powered Retrofit

**Policy makers**

- Manchester City Council Net Zero Team
- GMCA Low Carbon Buildings team

**Housing providers**

- Great Places

**Householders**

- Leaseholders
- Tenants

**Funders**

- Carbon Co-op
- MCS (Microgeneration Certification Scheme) Foundation

**Lenders**

- Manchester City Council – via Group Works Lending

**Technology providers**

- Powershaper Monitor
- Hildebrand

## Actions to carry forward to further work and the Alpha Phase

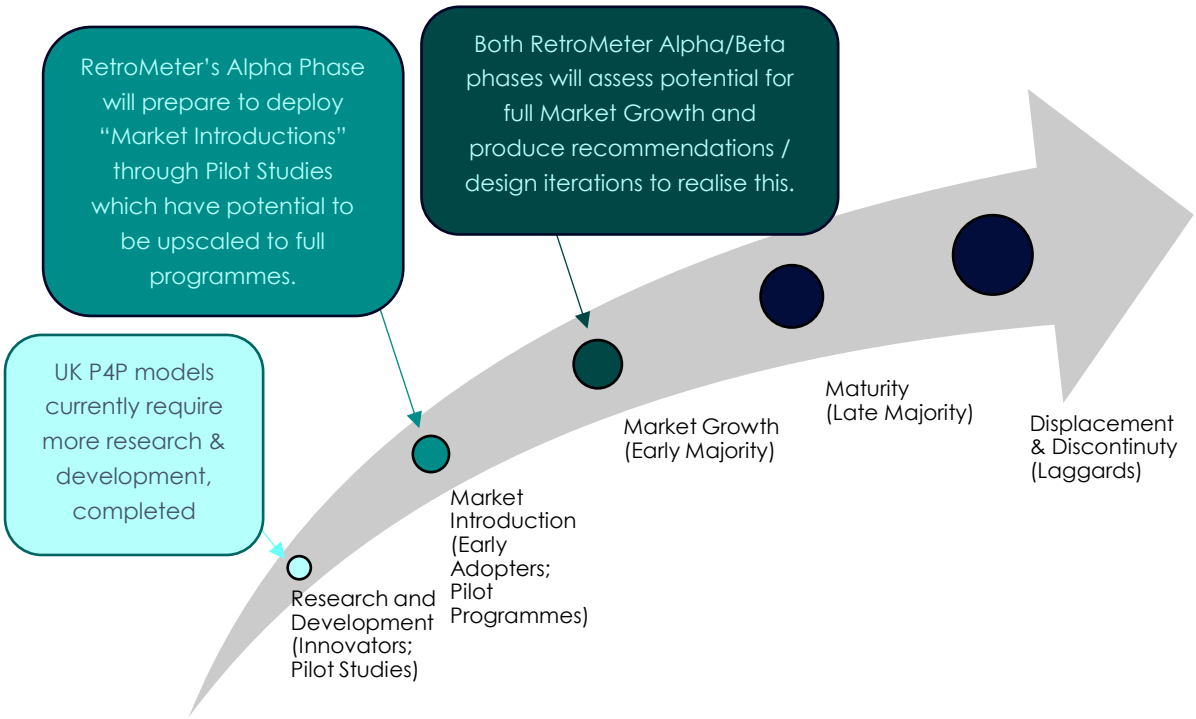
Now that we have identified the key stakeholders that will make the envisaged delivery models a success, we can begin to summarise the actions and outcomes to be carried forward into further work and the Alpha Phase. Following these recommendations, the upcoming section (Hypothesised delivery models for energy efficiency based on MES) will seek to understand the actors and stakeholder's whose engagement will help to realise this further work and insight.

1. Begin to map revenue streams onto specific stakeholders and launch conversations about the feasibility and details of realising these revenue streams.
2. Complete a final stakeholder map for the envisaged Alpha/Beta pilot schemes.

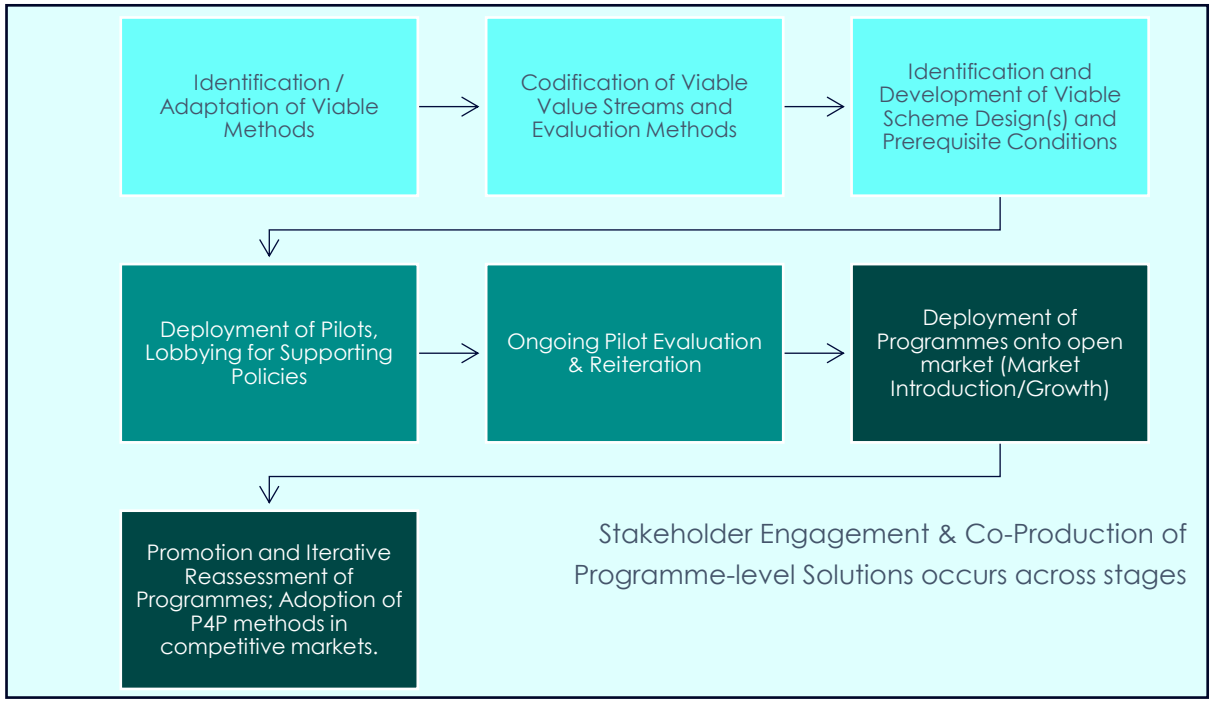
# Hypothesised delivery models for energy efficiency based on Metered Energy Savings

## Pilot Vs Programme: Defining Innovation Curves

The figure below shows a generic innovation curve and the current state of P4P delivery models within the British context:




Zooming in on the first 3 steps of the innovation curve, the figure below describes the steps that will support this progression:



This section is focused on the completion of "Research and Development" steps colour coded in light blue above, notably the final step "Identification and Development of Viable Scheme Design(s) and Prerequisite Conditions". However, in order to produce an integrated solution, there are several dependencies on other deliverables being developed by the RetroMeter consortium, listed below. These deliverables were scheduled to be completed in-line with this section, and have been reconciled within this deliverable and D3.9.

1) Viable Methods: WP2 Deliverables 1 and 3 .
2) Viable Value Streams and Evaluation Methods: WP2 Deliverable 2
3) Viable Scheme Design(s) and Prerequisite Conditions: WP3 Deliverable 1 – 4 ; Deliverable 6 .

Relevant Stakeholder Groups & Delivery Mechanisms: Manchester retrofit stakeholder mapping report: WP3 Deliverable 7 This work will then support the development steps and innovations described for Phase 2 and beyond, as colour coded in teal and dark green above. In order to narrow the "problem space" here and accelerate achievement of these development steps, it is useful to define some key use cases and delivery models to be examined further, as discussed in the following section. In addition, it is essential to focus on the barriers that have hampered retrofit delivery in UK markets to date, and to reveal how P4P approaches can address these barriers. Prior research has 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, pay-for-performance designs can help to address these barriers as:

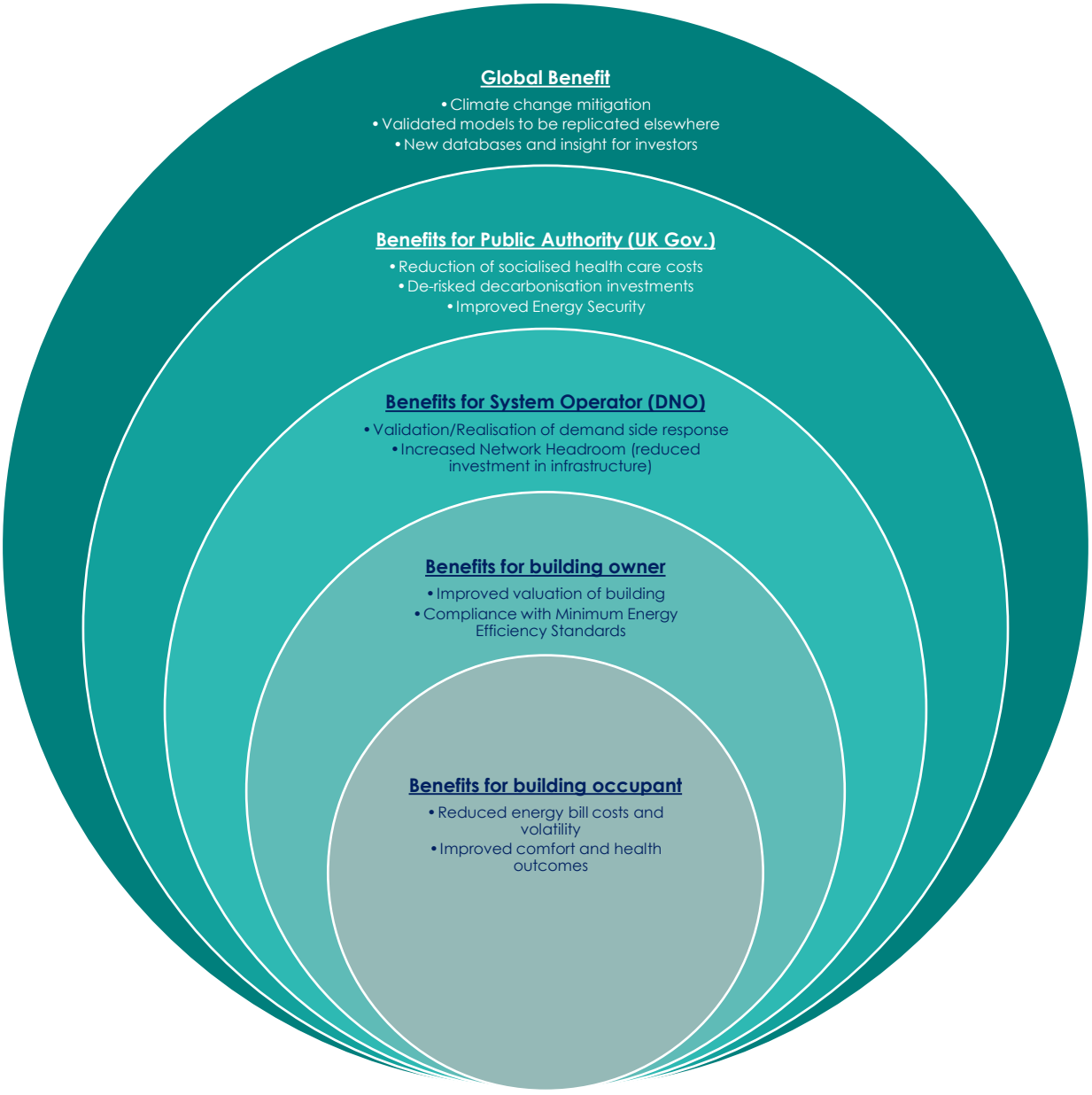
1) Government may be willing to invest more money in publicly funded programmes (such as the Social Housing Decarbonisation Fund (SHDF)) and similar retrofit schemes if robust data on success & performance outcomes is available.
2) P4P provides ongoing approach in which energy performance, and therefore 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. For example, P4P can do little to address complex householder motivations, the intricacies and experience required for successful service design, and the alignment of a retrofit supply chain that will need to be mainstreamed within an existing construction industry, much of which is fragmented and distributed across diverse markets. To explore these barriers further, the work of the report titled "Householder P4P demand assessment report" on the ENA Smarter Networks Portal (D3.2) is a key reference, along with the work of People-Powered Retrofit (Atkinson et al., 2019).

## Use Cases / Delivery Models to Date

P4P literature reviewed by the consortium (see Appendix) stated that "both metered energy savings and demand side response use cases could drive P4P schemes in the UK residential market". These two options represent distinctive use cases based on the permanence of the load reduction, with metered energy savings assumed to be "permanent" respective to the baseline period, whilst demand side responses (DSRs) are inherently transient depending on the DSR request from a network operator, relying on flexible assets such as storage heaters, air conditioners and heat pumps etc.

Each of these approaches has a different route to deliver value, and different value streams which are feasible to access and realise. In order to determine the benefits of various use cases in various market settings, the underlying components of a delivery model, these value streams must be mapped, as shown in the figure below, categorised at various scales:



Literature reviewed in the Appendix also stated that "a "Stacked" approach will likely be key for unlocking P4P schemes in the UK, with all key actors from Aggregators to ESCOs, Economic Agents, the Public Authority, the System Operator, the Fund and the Private Third Party Investors integrated". The table below therefore associates the categorised value streams above with each use case:

| | Demand Side Response | Metered Energy Savings |
|---|---|---|
| **Reduction of socialised health care costs** | | **X** |
| **Progress towards Net Zero** | **X** | **X** |
| **Improved Energy Security** | **X** | **X** |
| **Validation/Realisation of demand side response** | **X** | |
| **Increased Network Headroom (reduced investment in infrastructure)** | **X** | **X** |
| **Improved valuation of building** | | **X** |
| **Compliance with Minimum Energy Efficiency Standards** | | **X** |
| **Reduced energy bill costs and volatility** | **X** | **X** |
| **Improved comfort and health outcomes** | | **X** |

The table above shows that metered energy savings have access to a greater number of value streams, but this does not necessarily equate to greater value overall, as DSR values each kWh curtailed more than metered energy savings, where the latter is more constant and provides less evaluation of changing peak loads. The upcoming section of this report ("Hypothesising a UK Delivery Model") shall further develop the assessment of value streams above within the specific market scenarios and delivery options developed in upcoming sections.

In order to support the assessment of value streams, this section should propose one or more market segments and delivery options to be evaluated further. The following market segments are being assessed by UK innovation programmes, and so act as a useful starting point: *Social Housing Retrofit; Local Residential Retrofit (by building typology or measure) through Community Energy Groups; Retrofit of Non-traditional Residential Buildings (i.e. Permitted Developments that converted offices into residential units)*. The exercise above has been repeated for these market segments (table below), but as most value streams are in fact nested externalities, their value persists provided a market segment can access them.

| | Social Housing Retrofit | Local Residential Retrofit (by building typology or measure) through Community Energy Groups | Retrofit of Non-traditional Residential Buildings |
|---|---|---|---|
| Reduction of socialised health care costs | X | X | X |
| Progress towards Net Zero | X | X | X |
| Improved Energy Security | | X | X |
| Validation/Realisation of demand side response | X (hampered by data access) | X | X (hampered by metering arrangements) |

| | | | |
|---|---|---|---|
| Increased Network Headroom (reduced investment in infrastructure) | | X | X |
| Improved valuation of building | | X | X |
| Compliance with Minimum Energy Efficiency Standards | X | X | X |
| Reduced energy bill costs and volatility | X | X | X |
| Improved comfort and health outcomes | X | X | X |

Although the RetroMeter consortium is focused on the residential sector, learnings from the wastewater sector discussed briefly in the upcoming section (Hypothesising a UK Delivery Model) reveal interesting delivery models, such as the Asset Management Plan Period used to define framework durations, key performance indicators and price / incentive reviews for privatised water companies operating public assets. Standardised savings estimations are conducted to determine the best investments and savings potentials for the deployment of capital, which could be adapted into a reverse auction approach, whereby either public authorities or residential retrofit contractors codify project potentials, which are then used to allocate investments and set performance goals.

Insight and current UK best practice should be drawn in to develop a number of variations for delivery models within the segments highlighted above. These variations are outlined below, to be further hypothesised in the following section:

## Social Housing Retrofit

**1) Metered Social Benefits**: integrating/valuing comfort takebacks and improved health outcomes E.g. Warm Home Prescription programme piloted by Severn Wye Energy Agency & NHS Gloucestershire

**2) Metered stock uplift for large-scale social housing providers**: focused on incremental improvements and maximising cost-effectiveness for compliance with ECO / Energy Efficiency for Social Housing standard (latter is Scotland only, though consultation for the Minimum Energy Efficiency Standards to apply to English and Welsh social housing under consultation).

**3) Shared Savings from the flexible operation of social housing assets:** The social housing tenants identify their level of participation and which assets would be suitable for flexible control, (i.e. building-wide heat pump). A finance/deployment offer is developed to produce a significant flexibility / DSR resource to be deployed through specific contracts or a community aggregator.

| | |
|---|---|
| **Local Residential Retrofit** (by building typology /measure) | **4) Community-led Intermediary performance assurance (backed by LA or Gov.?):** A local community intermediary such as a community energy group, LEP or energy agency develops a retrofit offer based on a specific building typology/measure. Error, uncertainty and performance thresholds are then codified, with underperformances born in part by the local authority. |
| | **5) Community Scale Flexibility and Aggregation:** A local community or community energy group identifies flexible assets with good potential for uptake in a constrained network area, such as smart boilers or fridges. A finance or deployment offer is developed to produce a significant flexibility / DSR resource to be deployed through the community aggregator. |
| | **6) Metered Social Benefits**: integrating/valuing improved health outcomes and internal environment improvements (i.e. comfort) through specific measures or building typologies E.g. Warm Home Prescription programme piloted by Severn Wye Energy Agency & NHS Gloucestershire. Deployable both inside and outside of social housing settings. |
| **Retrofit of Non-traditional Domestic Buildings** *(i.e. timber or metal frame, on-site and pre-cast concrete)* | **7) Deep retrofit of "Off-gas" homes:** Although not identical to non-traditional construction, there are a large number of homes across the UK that have never been connected to the gas network. These homes will require detailed methods to verify savings from switching to solid and liquid fuels to electricity. This could build off of significant work carried out in the development of CalTRACK 2.1 which aims to include a methodology for considering delivered fuels such as propane and heating oil. |
| | **8) New build performance contracting:** Building new homes is expensive and complex, and so a high level of energy efficiency should be embedded in new designs, and verified through "metered savings" implementations of IPMVP option D. |
| | **9) Listed building specialisation (regional deployment of specialist measures or contractors):** Some regions will have a high concentration of non-traditional buildings, (such as permitted developments or listed buildings). Developing a metered energy savings method would accelerate decarbonisation in these hard to reach segments by enable performance measurement of sporadic retrofit approaches to date and standardisation of a quality-assured offer. |

In order to assess the above options further, we need to narrow down the 9 options to 2-3 delivery models for further consideration based on the suitability of launching first a pilot, then an upscaled programme. In order to do this, the table below provides a qualitative ranking (1 = low suitability; 3 = high suitability) for each based on 3 aspects: the **accessibility** of the market segment (how easy is it to find prospective customers which satisfy prerequisites such as access to historical data), the **acceptability** of the offer to customers and current market actors, such as DNOs & contractors (this will depend on the allocation of risk and the strength of incentives) and finally the **applicability** of the delivery model to the wider market (i.e. how easy is the offer to upscale or what is the abatement potential of the delivery model at the grid-level).

| Delivery Model Option | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| **Accessibility** | 1 | 2 | 1 | 3 | 2 | 2 | 2 | 3 | 1 (in MCC boundary) |
| **Acceptability** | 2 | 3 | 1 | 3 | 1 | 2 | 2 | 1 | 2 |
| **Applicability** | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Total Suitability Score** | **5** | **6** | **5** | **8** | **6** | **7** | **7** | **6** | **5** |

Based on the above analysis, the three delivery model options with the greatest suitability are as follows:

1) **Option 4 – Community-led Intermediary performance assurance (area-based):** A local community intermediary using an ESCO-like structure led by a community energy group, LEP, housing provider or community land trust (CLT) develops a retrofit offer based on a specific building typology/measure within a specific area. This will likely involve the able to pay [AtP] segment of that area's market but will also include projects funded through a combination of own funds and loans, pure loans and grant funding. Error, uncertainty and performance thresholds are then codified, with underperformances born in part by the local authority. The performance assurance and risk-sharing in domestic retrofits has occurred under similar models such as BHESCO's Retrofit Streets programme (BHESCo, 2023), and although more evidence is needed for the level of proportion of underperformance that LA's are willing to bear, this can be modelled using assumptions on the performance curves of a retrofit programme and the magnitude of value streams the LA captures. This structure is highly flexible to a range of local delivery models, including the Community Green Deal process or other forms of joint venture / place-based collaboration.
2) **Option 6 - Metered Social Benefits:** integrating/valuing comfort takebacks and improved health outcomes from non-social housing contexts through retrofit of specific building typologies or measures E.g. Warm Home Prescription programme piloted by Severn Wye Energy Agency & NHS Gloucestershire. This model would eventually be deployable both inside and outside of social housing settings.
3) **Option 7 - Deep retrofit of "Off-gas" homes:** There are a large number of homes across the UK that have never been connected to the gas network. These homes will require detailed methods to verify savings from switching to solid and liquid fuels to electricity.

However, at this stage we should defer consideration of Option 7 - Deep retrofit of "Off-gas" homes, as although this is an important part of the market, it will have very distinct data access and methodological requirements to Options 4 and 6. In addition, the proportion of homes in Manchester operating outside of the gas network is only ~3% (off gas AND solid walls), compared to the national average of 15% (URBED, 2011). As such there may be difficulties in finding suitable homes to enrol in the resultant pilot, and delivery of improvements through this pilot may result in a "postcode lottery" that increases the political and reputational risks faced by the pilot and delivery partners. As such the following section shall examine Options 4 and 6 in more detail. However, it is worth returning to Option 7 in later phases of this project: the nature of oil heating in terms of significantly elevated costs to the householder alongside elevated carbon emissions (compared on on-gas homes), mean this market segment has been treated differently (and more favourably) in past public schemes such as RHI and phase 2 of the Home Upgrade Grant (HUG) scheme.

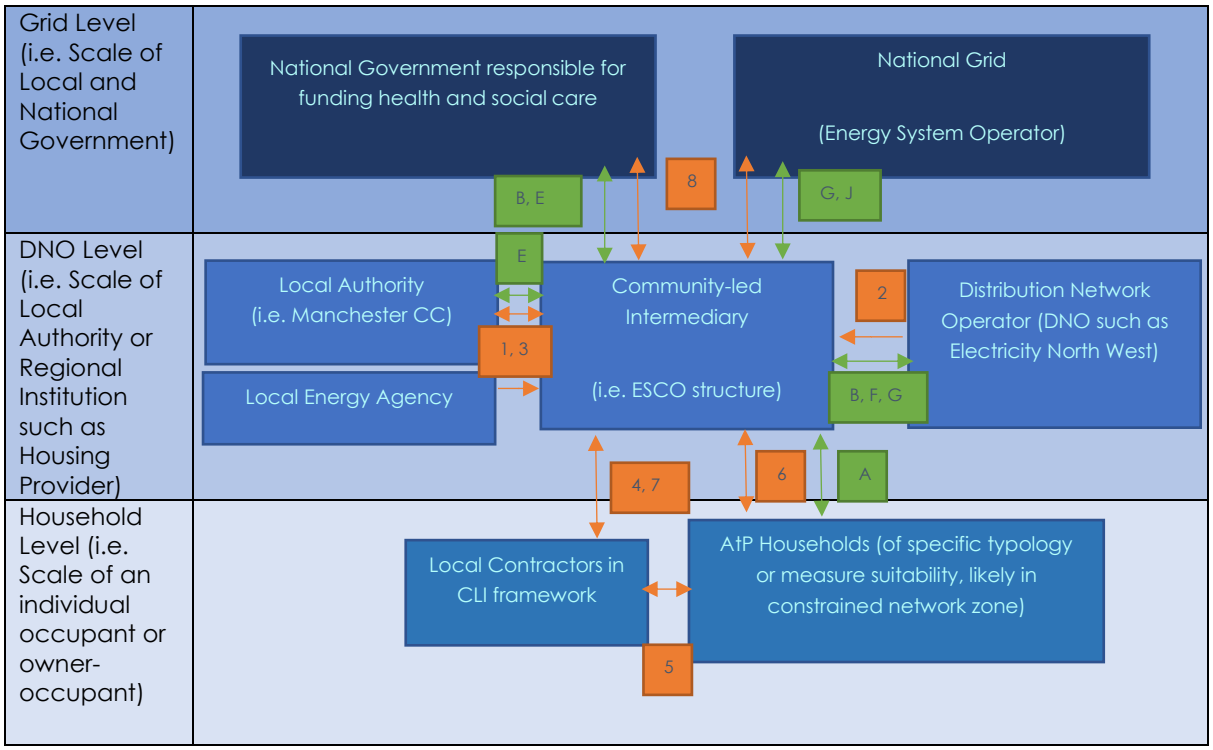
## Hypothesising a UK Delivery Model:

There is a need to explore what offers can be realistically realised in the beta phase of the RetroMeter SIF project, as this is separate but supportive of the broader P4P models identified to date: *a private sector area-based scheme with Carbon Coop acting as the community-led intermediary; and a Social Housing Decarbonisation Fund programme run by Manchester City Council*. This staggered approach will help us to demonstrate our innovation (MES in a

retrofit context), connect this innovation to DNO benefits and value for the SIF programme and ultimately inform financial and P4P models beyond the SIF project. Within the alpha and beta phase specific elements of delivery model will be explored and refined such as timing issues, accessing data from smart meter and other relevant sources, the underlying numerical methods, the wider process and project development specification that sits around the retrofit, the communicable concepts and the set of relationships needed to test metered energy savings in different contexts. This section concludes with a list of delivery model elements to be further developed, with a lens on understanding how further work can ensure these opportunities are ***achievable, robust, sustainable, transparent*** and ***equitable*** for all partners.

As such, this section shall review two UK delivery models in turn, and introduce some interesting permutations of these approaches in the Appendix. For each delivery model examined (I.e., Option 4/6 from the prior section), the arrangement of actors and revenue/value streams are shown as a organogram (Figures below and page 34). The revenue streams labelled A – L are then discussed further in the related tables (page 32-32 and 35-56 respectively), with each revenue stream colour coded by estimated significance within the delivery model. In order to clarify these value streams, a "delivery narrative" has been produced for each model, shown below each organogram. The appendix contains actor-level mappings of these revenue streams for each delivery model option.

The first model, for a Community-led Intermediary providing performance assurance (Option 4), is shown in the organogram below:




In order to deliver the value streams graphed above, the following steps should be taken. We should note these steps are not purely linear and that in reality the process will be more complex and likely iterative to put proper data access and specifications for baseline data in

place. The final process will require detailed thought around delivery design and finalised procedures, to be explored further at the conclusion of this report and in the alpha phase:

1) This model is likely initiated by the community-led intermediary (CLI), and potentially developed further with LA funding. Carbon Coop is already operating an area based scheme whilst one stop shops like People Powered Retrofit have existing models/platforms for owner occupier households. The role of the CLI is key in generating demand, recruiting householders, and as a source of trusted advice and support for occupants.
2) A DNO helps to identify constrained zones and peaks in the local load profile under the various Future Energy Scenarios. This provides an opportunity to explore electrification of heat accompanied by a package of fabric measures/demand reduction in comparison to prevalent scenarios which assume wide scale adoption of hydrogen fuel for domestic heating. From here the CLI proposes and models the impacts of targeting specific building typologies or energy improvement measures, which are confirmed with the DNO.
3) Error, uncertainty and performance thresholds are then codified by the CLI, and an underperformance compensation scheme developed to de-risk projects to an acceptable level for contractors, with costs born in part by the local authority.
4) Contractors develop quotes and performance estimations in response to the defined retrofit offer (based on a specific building typology/measure). These are accepted or rejected by the ESCO-like CLI.
5) Works commence and performance is "metered".
6) AtP households receive energy bill reductions, the financial benefits and underlying data for which may then shared in part with the ESCO who can use these alongside other datapoints to determine project performance
7) The contractor receives a performance-incentive payment. This may be minimal or born by the LA if the project underperformed.
8) Performance data at project and network levels are provided to DNOs and National Grid ESO. Information on health outcomes is derived or produced by National and Local Government, motivating further engagement or performance payments. Following phases of this research will examine whether this value should be defined using "standard" social value metrics or specific local outcomes (such as reduction in GP visits). This is notable as prior schemes such as that launched in Oldham (Stephens, 2018) have struggled to access the data required to demonstrate outcomes and the definition of fuel poverty had shifted across the duration of the scheme. We should note that these value streams may be captured by the CLI for reinvestment; e.g. "For every individual lifted out of fuel poverty, Oldham CCG allocated £250 and Oldham Council £50 to fund the future project. During the first three years fuel poverty targets were met, so the £300,000 payment by results for year three was made available for reinvestment in year four".

Completing the above delivery steps will help to realise the value streams listed below in Tables below (derived from energy efficiency or avoided consumption with no temporal aspect) and overleaf (those derived from "flexibility" or grid services where energy balances are modified in real time). Please note that not all of these value streams will be included in the final delivery model, though green and amber revenues are more likely to form part of the "core" set for the model.

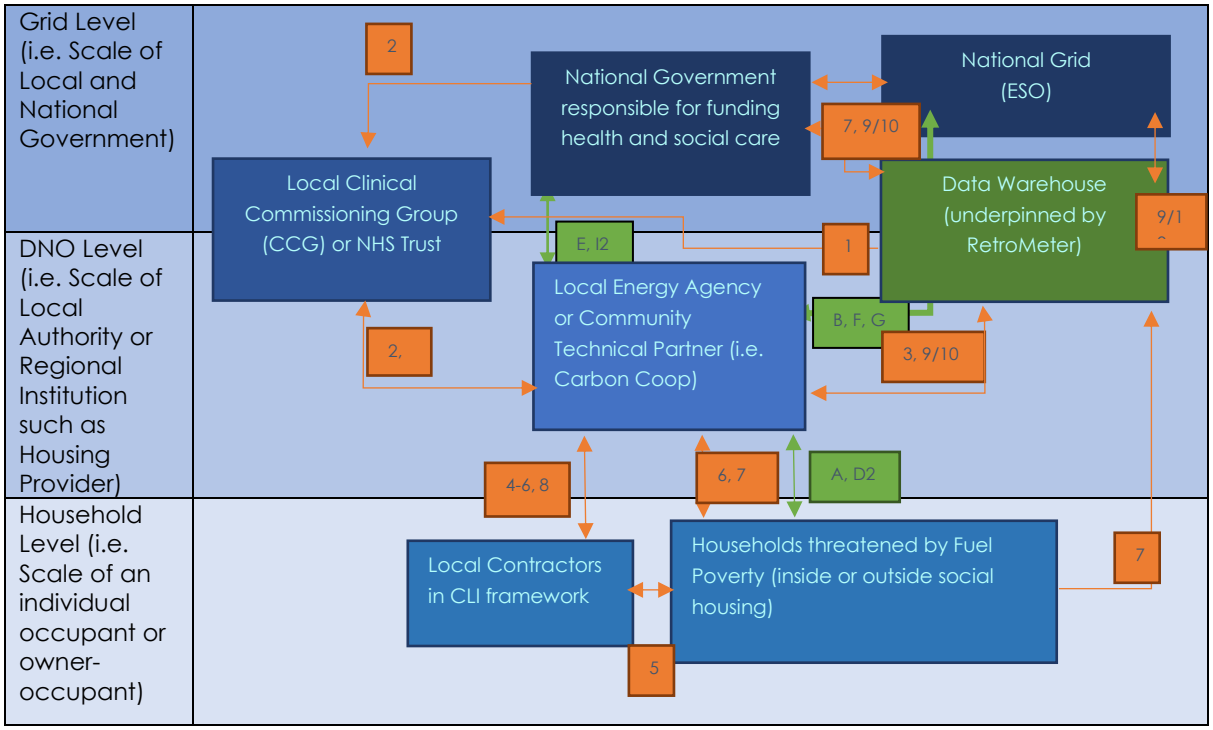
| Value / Revenue Stream | Scale or Level of Benefit (Grid/DNO /Household) | Market Status | Valorised through: | Realised Through |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Load Reduction (Energy cost savings) **[A]** | Household (Occupant) | Proven | Cost abatements; EPC; Shared Savings; Performance Bonus / Malus | RetroMeter |
| Identification of Non-Routine Consumption (underheating) **[B]** | Grid / DNO (Government responsible for health and social care and grid actors responsible for asset deployment). | Proven | Improvement of network forecasting and deployment of assets where most needed. Improved Social Prescribing avoids healthcare costs. | Data Warehouse |
| Increase in real estate / rental value (housing provider or community land trust only) **[C]** | Household or DNO (depending on whether Building Owner is occupant or landlord, with latter able to reinvest in wider stock) | Proven | Capital Gains and Rental Agreements | Data Warehouse |
| EPC Uplift (housing provider or community land trust only) **[D]** | Building Owner (depending on whether Building Owner is occupant or landlord, with latter able to reinvest in wider stock) | Piloted | Performance Contracts | Data Warehouse |
| Emissions Reductions and Improved Environment (including Air Quality) **[E]** | DNO/Household (local government and occupant respectively) | Proven (ETS etc) | Emissions Trading/Insetting, Subsidies. Improved air quality / indoor environment avoids healthcare costs. | Data Warehouse |
| Deferred Network Reinforcement (Load Reductions) **[F]** | DNO/Household (occupant benefits through reduced network charges on bill) | Piloted | Deferral of network reinforcement costs, Reduced need for load curtailment/expensive flexibility services. | RetroMeter & Data Warehouse |

| Value / Revenue Stream | Who Benefits / Pays? | Market Status | Valorised through: | Realised through: |
|---|---|---|---|---|
| Peak Capacity Uplift / Load Shaping (deferred network reinforcement) **[G]** | DNO / Household. (latter via reduced network costs.) | Proven | Arbitrage; Performance contracts (capacity margin KPI) | Data Warehouse |
| Provision of Implicit Flexibility (initiated by occupant, only for specific measures) **[H]** | DNO / Household. (latter via reduced network costs or flex. payments) | Proven | Performance Contracts / Reverse Auctions (reserve value KPI) | RetroMeter and Data Warehouse |
| Provision of Explicit Flexibility (initiated by building owner/operator, only for specific measures) **[I]** | DNO / Household. (latter via reduced network costs or flex. payments) | Proven | Performance Contracts / Reverse Auctions (reserve value KPI) | RetroMeter and Data Warehouse |
| Reduced Public Infrastructure Costs (i.e. increased cost effectiveness of deployed infrastructure) **[J]** | DNO / TNO. Consumers via network costs. | Unproven | Reduced Externalities (network charges) | Data Warehouse |
| Avoided demand / connection charges (only for housing providers / CLT) **[K]** | Building Owner / Occupant | Proven | Reduced demand charges. Reduced connection charges. | RetroMeter |
| Reduced private infrastructure costs (EVs / REG) (only for housing providers / CLT) **[L]** | Building Owner / Occupant | Piloted | Self consumption turn up (avoided import), Arbitrage. | RetroMeter and Data Warehouse |

We should note that Option 4 is highly flexible to a range of local delivery models, including the Community Green Deal process (URBED, 2011) or other forms of joint venture / place-based collaboration. In addition, when drawing out key differences between Options 4 & 6, in the former case private sector homeowners are the core "client", with their requirements assured by public sector and ESCo-like intermediary. Although other tenures can then be explored, this approach can build a more commercial approach where the roles of various actors can be integrated, and risk distributed. This commercial engagement then generates detailed performance data from "real market" conditions, which can then be capitalised by networks and centralised institutions.

In contrast, the public sector are the core client for Option 6, with value gathered through "big" performance data summarising changes to average load, load profile, and occupant health outcomes as relating to indoor environment quality. These are monetised through social prescription approach (prescribing or contributing to the retrofit cost) and provision of "big" data, modelling and verifying future project impacts across the grid and local housing stocks. Option 6 could be targeted at households facing fuel poverty, as demonstrated by the Warm Home Prescription programme piloted by Severn Wye Energy Agency & NHS Gloucestershire. Alternatively, the model could be used to deploy and assess improvements through the Social Housing Decarbonisation Fund, which aims to improve homes to EPC band C and space heating demand level of 90 kwh/m2/year where reasonable and cost effective. However at its core, the idea is it is multi-tenure - so, can be a stack on income streams including Energy Company Obligation scheme (ECO), DNO funds, householder contributions, LA lending etc; as well as the core social benefits it aims to deliver. UK Government intended to introduce a P4P element to ECO4 (Department for Business, Energy & Industrial Strategy (BEIS), 2021), but this has yet to be confirmed, therefore there is good potential for this project to inform future learnings & integration within the ECO4 programme.



In order to deliver the value streams graphed above, the following steps should be taken:

1) If a data warehouse is available, summaries of project impacts on indoor environment quality and internal temperature changes (likely derived from heating system efficiency or heat transfer coefficient [HTC]) will be made available in order to help with quantifying the value of social prescription of building/energy improvements.
2) CCCG or local NHS trust establishes social prescribing programme / scheme to outline the target segment (geography, income range/ability to pay, EPC rating or description of indoor environment thresholds to trigger support).
3) Local Energy Agency or Community Technical Partner (CTP) responds to social prescribing programme with a defined retrofit offer integrating specific building typologies or measures. This could be flexible to a range of measures that will satisfy an improvement of another KPI, such as HTC.
4) Contractors provide set quotes for the defined offer and market segment (i.e. pre-1930s tenement/terraced homes), providing cost and performance ranges that are ready to be deployed. These set quotes may be based off of the pre-defined specification but will likely still involve a more detailed whole house assessment as a follow up. This assessment ensures suitability of measures - for home and occupants, and allows more accurate baselining. This is a key step as it informs the contractor's design work, ensuring they liable for both the design and it's assured outcomes.
5) Retrofits are prescribed and the Community Technical Partner selects the most relevant quote based on the contractor's estimations and specifications of building performance improvements alongside a range of other procurement factors.
6) Works commence and performance is "metered".
7) Households receive a follow-up comfort survey and request for feedback alongside energy cost reductions/completion tests. Energy consumption and any KPI/IEQ data is then shared with the ESCO and related data warehouse who can use these alongside other datapoints and novel methods to determine project performance. More conceptual development and stakeholder mapping is required (for example connecting the TrustMark database), but national or local governments could then fund the maintenance and access of this warehouse. Upon reaching maturity, this data warehouse could be monetised through other routes, such as in return for providing insight to housing providers.
8) The contractor receives a performance-incentive payment based on completion tests or numerical outputs. This may be minimal if the project underperformed.
9) Performance data at project and network levels are provided to DNOs and National Grid ESO. Information on health outcomes is derived or produced by National and Local Government or other relevant bodies (depending on metrics produced), motivating further engagement or performance payments.
10) Further pilot or public schemes are run in the housing segment, with RetroMeter enabling the M&V of these services. This could include additional payments to "maintain" the baseline and reporting period data.

Completing the above delivery steps will help to realise the value streams listed below in The tables below (derived from energy efficiency or avoided consumption with no temporal aspect) and overleaf (those derived from "flexibility" or grid services where energy balances are modified in real time). Again, please note that not all of these value streams with be included in the final delivery model, though green and amber revenues are more likely to form part of the "core" set for the model.

| Value / Revenue Stream | Who Benefits / Pays? | Market Status | Valorised through: | Realised Through |
|---|---|---|---|---|
| Load Reduction (Energy cost savings) **[A]** | Occupant | Proven | Cost abatements; EPC; Shared Savings; Performance Bonus / Malus | RetroMeter |
| Identification of Non-Routine Consumption (underheating) **[B]** | Owner / Occupant (depending on responsibility) | Proven | Improvement of network forecasting and deployment of assets where most needed | Data Warehouse |
| EPC Uplift (housing provider or community land trust only) **[D]** | Building Owner | Piloted | Performance Contracts | Data Warehouse |
| Comfort Improvements **[D2]** | Occupant | Piloted (Mbenefits and other R&D) | Enhanced Performance Contracts, Internal Processes | RetroMeter and Data Warehouse |
| Emissions Reductions and Improved Environment (including Air Quality) **[E]** | Occupant / Government. Local Public. | Proven (ETS etc) | Emissions Trading/Insetting, Subsidies. | Data Warehouse |
| Deferred Network Reinforcement (Load Reductions) **[F]** | Occupants via Network Charges | Piloted | Deferral of network reinforcement costs, Reduced need for load curtailment and expensive flexibility services. | RetroMeter and Data Warehouse |

| Value / Revenue Stream | Who Benefits / Pays? | Market Status | Valorised through: | Realised through: |
|---|---|---|---|---|
| Peak Capacity Uplift / Load Shaping (deferred network reinforcement) **[G]** | DNO / TNO. Consumers via network costs. | Proven | Arbitrage; Performance contracts (capacity margin KPI) | Data Warehouse |
| Provision of Implicit Flexibility (initiated by occupant, only for specific measures and not priority) **[H]** | DNO / TNO. Consumers via network costs. | Proven | Performance Contracts / Reverse Auctions (reserve value KPI) | RetroMeter and Data Warehouse |
| Provision of Explicit Flexibility (initiated by building owner/operator, only for specific measures and not priority) **[I]** | DNO / TNO. Consumers via network costs. | Proven | Performance Contracts / Reverse Auctions (reserve value KPI) | RetroMeter and Data Warehouse |

| | | | | |
|---|---|---|---|---|
| Emissions/Air Quality Improvements (near power stations providing containment / capacity reserve) **[I2]** | Government. Local Public (local to power station, not project site) | Unproven | Reduced Externalities (costs of disability adjusted years lost, health care, climate adaptation / mitigation) | N/A |
| Reduced Public Infrastructure Costs **[J]** | DNO / TNO. Consumers via network costs. | Unproven | Reduced Externalities (network charges) | Data Warehouse |
| Avoided demand / connection charges **[K]** | Building Owner / Occupant | Proven | Reduced demand charges. Reduced connection charges. | RetroMeter |

Along with the models discussed above, a permutation of each has been produced and described in the Appendix. Pages 49-51 show a variation of the area-based scheme involving a Housing Provider installing measures providing both explicit and implicit flexibility (with the former occurring rapidly, initiated by building owner/operator where suitable assets are available; whilst the latter is initiated by the occupant and occurs over human timescales). Pages 52-55 show a permutation of the Metered Social Benefits approach when seeded with Social Housing Decarbonisation Funding. This case allows further measurement and verification of publicly funded projects, enabling further data collection and diversification of revenues. In addition, pages 56 onwards of the Appendix map the actors underpinning each revenue stream, enabling further permutations of these delivery models to be considered and assembled.

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 component 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 P$P schemes ensure it plays a central role.

## Remaining Questions and Recommendations:

This document has now identified an innovation curve 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 were then 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.

This will enable the financial implications of these delivery models to be further evaluated and 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)
- **Core structure**

- **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.

➢ **Performance assessment Methods**

- **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.

➢ **Payment structure and schedules**

- **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.

➢ **Supporting Factors:** These are outlined above but include development of standardised indicators, uncertainty thresholds, requirements for governance procedures or stakeholder engagement etc.

## Actions to carry forward to further work and the Alpha Phase

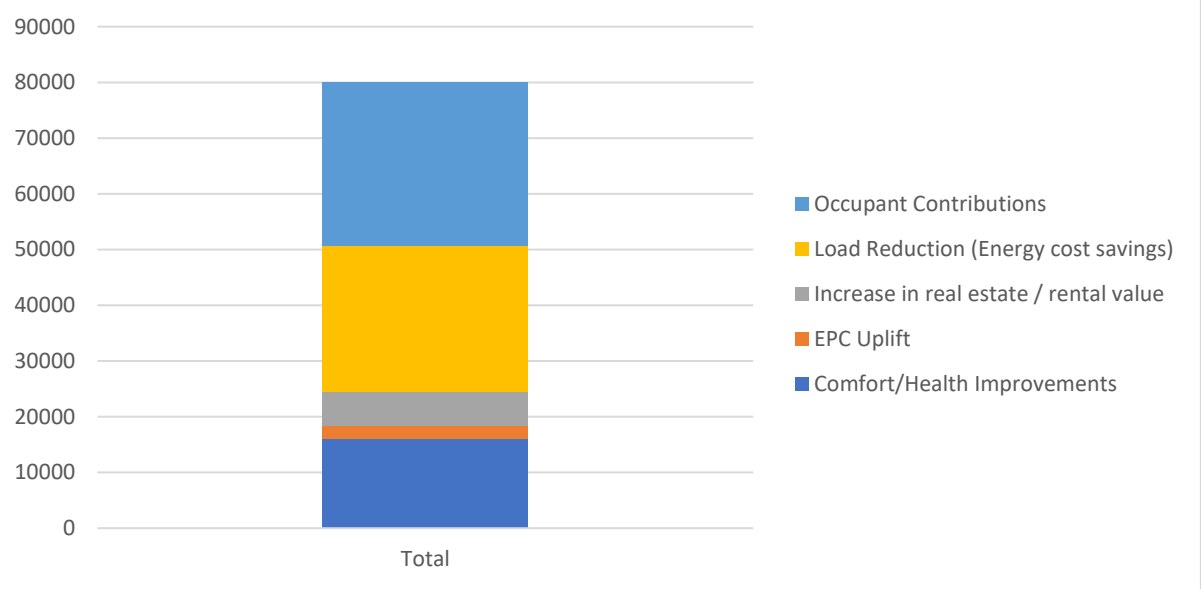
Now that we have identified the key stakeholders that will make the envisaged delivery models a success, we can begin to summarise the actions and outcomes to be carried forward into further work and the Alpha Phase. Following these recommendations, the upcoming section (Hypothesised delivery models for energy efficiency based on MES) will seek to understand the actors and stakeholder's whose engagement will help to realise this further work and insight.

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.
3. Propose deliver models and their variants that cover the full innovation curve.
4. 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

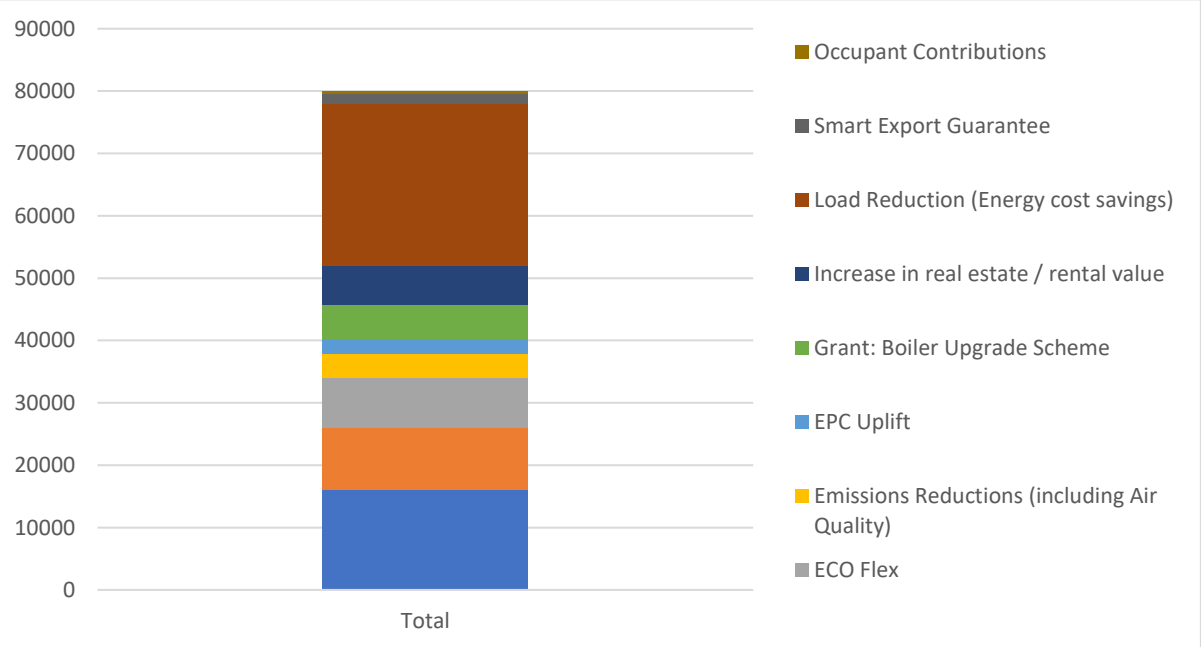
# Scenario value estimates of proposed delivery options

This section shows a number of scenario value estimates for a exemplary retrofit of a 2 bedroom maisonette in Oldham, Manchester. This exemplary 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, as well as supplementary calculations demonstrating possible values per kW of avoided capacity or home retrofit.

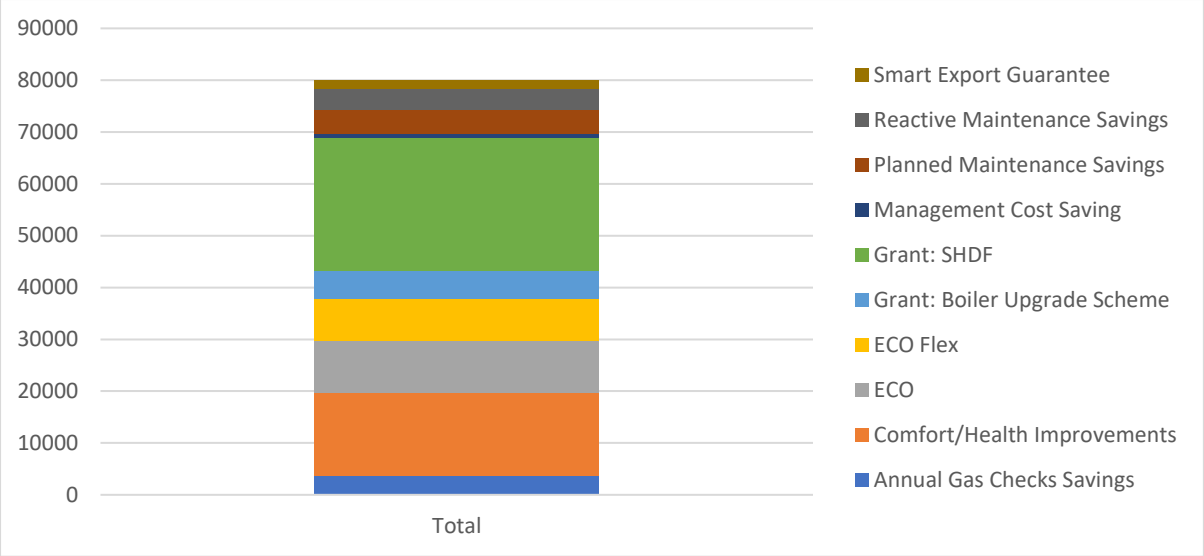
***Area Based Scheme (core revenues only)***



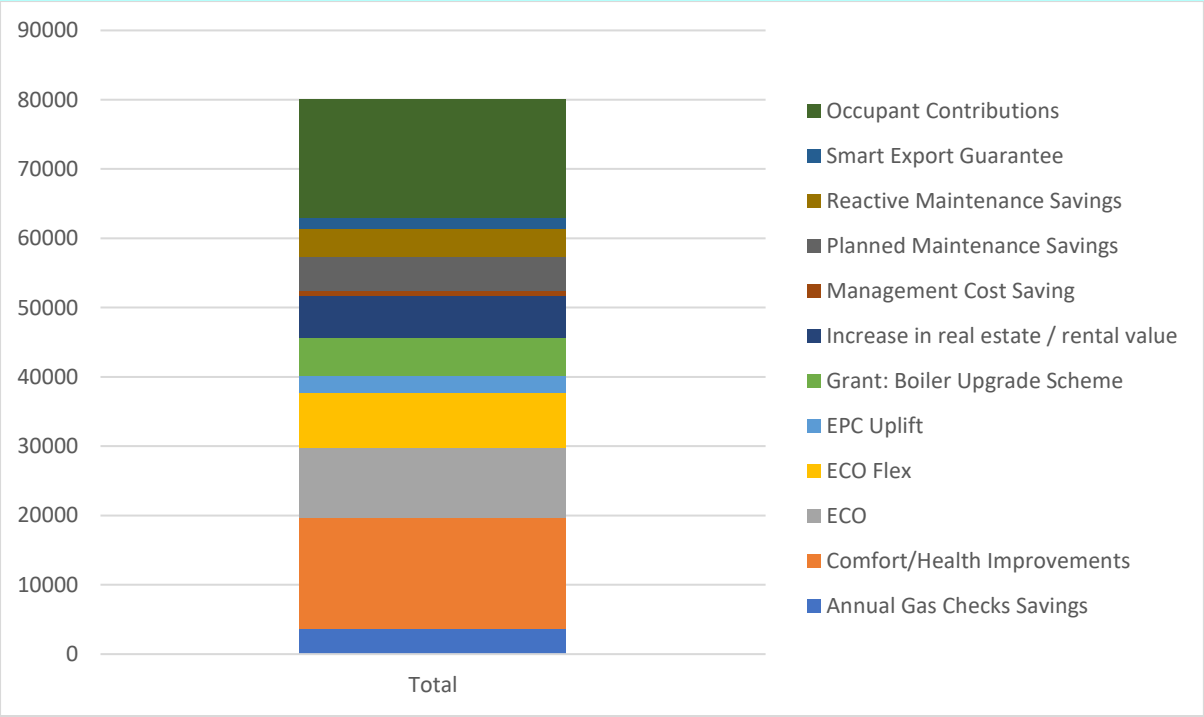

***Area-based Scheme (Flexibility and Housing Provider revenues):***



***Metered Social Benefits (core revenues including SHDF)***




***Metered Social Benefits (SHDF replaced by householder contributions).***




Together these demonstrate the various routes to fund a retrofit of a single home in Manchester. However, we should also consider a risk matrix for the hypothesised delivery models, as shown by the table below.

| Revenue Description | Likelihood of Impact with mitigation | Mitigation |
|---|---|---|
| Load Reduction (Energy cost savings) | Low | Verifiable savings, energy price modelling |
| Identification of Non-Routine Consumption (underheating) | Low | Good dialogue with both occupants and network operators |

| | | |
|---|---|---|
| Increase in real estate / rental value | Low | Ensure any increase is affordable for tenants |
| EPC Uplift | Medium | Monitor discussions relating to MEES compliance |
| Comfort/Health Improvements | Medium | Maintain good dialogue with NHS trusts and CCGs and pre-agree who will analyse outcomes, the level of confidence and the data sources |
| Emissions Reductions (including Air Quality) | Low | Verifiable savings, modelling of grid emissions factors |
| Deferred Network Reinforcement (Load Reductions) | Medium | Verifiable savings, Energy demand modelling |
| Peak Capacity Uplift / Load Shaping (deferred network reinforcement) | Low | Verifiable intraday savings, Energy demand modelling |
| Provision of Implicit Flexibility | Medium | Verifiable load shifts, certainty and error thresholds, dispute resolution mechanisms, thresholds for activating flexibility, dialogue with occupants |
| Provision of Explicit Flexibility | Low | Verifiable load shifts, certainty and error thresholds, dialogue with occupants |
| Emissions/Air Quality Improvements (near power stations providing containment / capacity reserve) | High | Verifiable savings, modelling of grid emissions factors and point sources |
| Reduced Public Infrastructure Costs | High | Verifiable savings, Energy demand modelling, Iterative Data Warehouse |
| Avoided demand / connection charges | Low | Verifiable load reductions |
| Reduced private infrastructure costs (EVs / REG) | Medium | Data Warehouse, dialogue with occupants/owners |
| Planned Maintenance Savings | Low | Iterative Monitoring, Improved Forecasting and business case analysis |
| Reactive Maintenance Savings | Medium | Iterative Monitoring, Improved Forecasting and business case analysis |
| Annual Gas Checks Savings | Low | Iterative Monitoring, Improved Forecasting and business case analysis |
| Management Cost Saving | Medium | Iterative Monitoring, Improved Forecasting and business case analysis |
| Smart Export Guarantee | Low | Dialogues with energy suppliers |
| ECO | Medium | Dialogues with energy suppliers/LAs |
| ECO Flex | Medium | Dialogues with energy suppliers/LAs |
| Grant: Boiler Upgrade Scheme | Low | Monitoring policy changes |
| Grant: SHDF | Low | Monitoring policy changes |
| Occupant Contributions | Medium | Financial modelling to ensure affordability, dialogue with occupants |

# Appendix

The following key sources were identified to assist with meeting the objectives of this literature review. The table below helps to categorise these sources and identify the market segments and use cases which each P4P programme has examined:

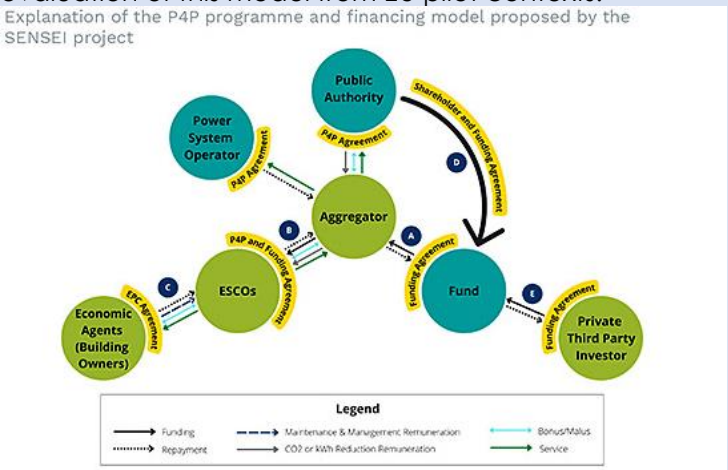
Source: SENSEI

Description: SENSEI has been investigating the use of Pay-for-Performance (P4P) schemes to aggregate retrofit projects, improve the effectiveness of subsidy programmes, and reward energy efficiency as an energy resource and a grid service. Based on the lessons learned from the US, where P4P has been applied for many years, SENSEI has been developing knowledge and insights into how P4P can benefit market players such as ESCO's, building owners and energy providers and not least, how improving energy efficiency rates can help us all reach the climate goals and mitigate the energy crisis.

Comments:

- This source has deep insight into P4P models, both from the US and from extrapolations of this insight across EU contexts.
- The source proposes a specific P4P model for the EU but has not yet published an evaluation of this model from EU pilot contexts:

Explanation of the P4P programme and financing model proposed by the SENSEI project




- The source takes a holistic view on realising the value of P4P programmes, with key outputs that will assist this literature review in identifying the characteristics and conditions to realise P4P models. These outputs include the following deliverables:
  - Policy developments in the European Union and strategies for Pay-for-Performance business models
  - Guidelines for the design of effective P4P rate structures
  - The Boundary Cases for the P4P Rates
  - Experience and Lessons Learned from Pay-for-Performance (P4P) pilots for Energy Efficiency
  - The ex-ante evaluation of financial benefits in the SENSEI P4P scheme
  - The drivers of the value of energy efficiency as an energy resource
  - Proposal on the specifications for P4P project data

Market Segments and Use Cases Examined:

- The SENSEI project takes a "Stacked" approach, suggesting a basic European P4P model that includes Aggregators at the model's centre, alongside ESCOs, Economic Agents, the Public Authority, the System Operator, the Fund and the Private Third Party

Investors. The aggregator should coordinate the projects and assure outcomes, for which they receive an agreed remuneration (e.g. EUR/kWh or EUR/ tCO2) from the Public Authority.
- Within the P4P model, there is a certain degree of flexibility in terms of funding opportunities, such as direct funding of Aggregators by Private Third Party Investors, of ESCOs by the Fund, or of Economic Agents by the Fund. The feasibility of a particular financing programme often depends on a combination of factors, from project size and anticipated payback period to utility incentives/rebates and security features.
- The model does not specify any specific market segments but focuses on energy efficiency in buildings, particularly in contexts where compliance with Energy Efficiency Obligations need to be measured and verified.

Key Takeaways:

- Developing innovative business models related to energy renovation measures, such as P4P schemes, is necessary for the future of the EU energy system. However, market conditions and current national legislative frameworks across the EU are not as supportive or receptive as they could be toward performance-based energy efficiency schemes. Source.
    - A list of 10 specific policy measures was proposed to facilitate the rollout of European P4P.
- It is essential P4P schemes have a Catalogue of Quantified and Qualified Measures broad enough to be used as a decision tool. This does not replace the assessment of individual or aggregated cases but is used to classify & categorise measures by typology & suitability.
- Aggregation is key to mitigating variability and risk, but establishing the aggregation criteria for projects may be influenced by the payment structures for a specific typology of measures or market segments.
- Residential retrofit is a more difficult sector for P4P, as investments are high and are accompanied by reluctance or insecurity from homeowners. Aggregators must have the knowledge to establish aggregation criteria at the same time as sufficient tools for evaluating and building energy efficiency plans when engaging new customer segments. Indicators are one such key tool for monitoring, controlling and forecasting P4P programmes.
- The objectives of public bodies must be engrained in incentive structures and governance models to ensure public value is realised and measured. The public body should determine how the objectives are achieved and progress compensated, with methods for this available in SENSEI D4.4. This should also integrate the evaluation of environmental and social needs, and should embody the promotion of energy culture and environmental education in many market segments.
- The governance model must make it possible to identify, evaluate and respond to contractual, fiscal, cultural and economic barriers that at certain times could hamper the deployment of P4P models. For example, if the scope of action includes the residential sector, this sector benefits where living conditions have improved, improving the comfort of the home and reducing energy bills. However, the sector could also be harmed, e.g. if increases to home values negatively impact occupant taxes or income.
- SENSEI provides key methods for quantifying and monetising the benefits of P4P schemes, and methods for ex-ante evaluation based on these multiple benefits:
    - energy cost savings,
    - employee productivity increase due to increase comfort
    - increased building value,
    - optimized operation and maintenance costs,
    - avoided costs for the power system.
- SENSEI provide descriptions of key data and indicators needed to design, deliver and evaluate P4P schemes.

Source: UK Government's "Heat Pump Ready Programme", Stream 2 outputs.

Description: The Heat Pump Ready Programme (part of BEIS' £1 billion Net Zero Innovation Portfolio) aims to accelerate the commercialisation of innovative clean energy

technologies and processes (such as low-carbon heat provision) through the 2020s and 2030s. Heat Pump Ready will support the development of innovative solutions across the heat pump sector and is aligned with other BEIS NZIP Programmes, in addition to Ofgem's Network Innovation Fund (NIC) and the Strategic Innovation Fund (SIF), delivered in partnership with Innovate UK (funding this work).

The Heat Pump Ready Programme is split into 3 separate delivery streams, of which we are currently mostly interested in the outputs of Stream 2.:

- Stream 1: solutions for high-density heat pump deployment. Up to £30 million of Small Business Research Initiative (SBRI) funding from spring 2022, which will support the development and trial of solutions and methodologies for the optimised deployment of domestic heat pumps at high-density.
- Stream 2: developing tools and technology. Up to £25 million of grant funding for projects to overcome barriers to heat pump deployment, beginning spring 2022
- Stream 3: trial support and learning. Up to £5 million contract from spring 2022

Comments:

- There is minimal information from Stream 1 available at this time, as the contracted length of the project runs until 2025. One key pilot running in Fenland may be valuable to observe. The "PACE Financing for Heat Pumps in Rural Cambridgeshire" will be looking to improve repeatability of performance and evaluate impacts on the national grid, which may assist with launching P4P models as discussed here.
- There are a number of relevant Projects for Stream 2 of the programme, although final deliverables will not be available until 2025, these are listed in the section below.

Market Segments and Use Cases Examined:

- Heat-as-a-Service *(City Science Corporation Limited - Advanced Modelling for Heat as a Service)*
- Social Housing *(Switchee Ltd. - Digitising the Customer Journey of Heat Pumps in Social Housing; Guru Systems Ltd - Guru Smart Heat Pumps: developing tools for social housing landlords to enable heat pump installation at scale across the UK)*
- Community Energy *(Hildebrand Technology Ltd - Glow Heat Pump Community)*
- Retrofit of Non-traditional Buildings *(RJ Barwick Ltd - Archetypal Heat Pump Retrofit for 175,000 Non-Trads)*
- Wastewater/Water Treatment *(Thermoelectric Conversion Systems Ltd - Two stage heat pump with greywater energy recovery)*

Key Takeaways:

- 2025 is the key date for public monitoring of these projects, but the RetroMeter consortium should consider engaging some project partners from these trials to gain early insight.
- The UK sees heat pumps playing a key role in decarbonisation of both domestic and non-domestic heat, and so this should be evaluated within any P4P models proposed by this project where possible.
- The deployment of heat pumps will be evaluated in a range of market segments, and learnings from these edge cases should be monitored for extrapolation into the domestic sector.
- These projects may have access to important data sources that could complement the RetroMeter work, particularly around control groups and contextual information.

Source: BENV0006: MSc EPEE Dissertation: *"The (Cal)track to energy efficiency? An investigation into the potential of one M&V 2.0 method to underpin a pay-for-performance programme in the UK residential buildings sector."*

Description: James Fenna (JF: Author of the source in question) is an expert in metered savings methodologies within the UK, and contributed greatly to the preliminary work this

consortium has conducted. JF was employed at Carbon Coop during the pre-launch stages of this project, but was transitioning to a new role at the time of writing. JF kindly offered access to the aforementioned dissertation to assist with the review of literature relevant to the P4P topic.

Comments:

- This is a powerful document with a comprehensive methodological review of M&V2.0 and P4P methods developed around the work.
- The author examines the role of different actors in P4P delivery models, in particular connecting deferral of medium-term risk onto local governments with "cherry picking" by contractors and project initiators, where only low-risk buildings and measures are implemented.
- This source reveals major issues with applying CalTrack methods "as-is" to the UK market as part of a P4P pilot, mainly due to inaccuracies and systemic underprediction present in both the hourly and daily model. When operating at the level of an individual household, CalTrack was not are not sufficiently calibrated to generate savings estimates even when disregarding evidence of systematic underprediction.
- The author states "implementing [CalTrack] methods to support a P4P programme as they currently stand could therefore create significant problems for consumers in a P4P system."
- The thesis proposes a range of alternative use cases for the CalTrack methods which could be used to adapt or support a P4P model.

Market Segments and Use Cases Examined:

- Residential (demand side response, metered energy savings)
- Non-Residential (evaluation of industrial and commercial savings estimation methods)
- Implementation studies from the USA, Spain, Italy, Norway and across the wider EU were assessed

Key Takeaways:

- OpenEEMeter is not currently sufficiently calibrated to support a UK P4P programme involving either household- or portfolio-level calculation of metered energy savings.
- CalTrack methods performed reasonably well with electricity data, but poorly with gas data, limiting their utility in UK residential contexts.
- Strong intra-day modelling of electricity usage could "have immediate applications in the power sector for DSR solutions, though further work in resolving double-penalty effects may be required if household-level DSR solutions are to be pursued."
- "OpenEEMeter hourly model missed test-period P4P compliance only marginally for electricity data, and it may be possible to build in adjustments to support a portfolio-level P4P programme."
    - Large scale gas datasets will be needed to validate this, and may need to adjust for permanent NREs using comparison groups. Murphy et al.'s assessment of R-PACE and Ciccone et al.'s evaluation of PG&E's residential P4P programme provides an exemplar route to do this.
- Baseline accuracy may also be improved by "incorporating assumptions regarding diurnal heating patterns alongside more complex modelling approaches such as gradient boosting machines or dynamic time-warping".
- UK-specific error and uncertainty thresholds should be developed and clearly specified to support a functioning P4P market.
- The UK should consider subsidising performance risk at national level, potentially developing on the thresholds established by this source and the M&V2.0 programme. This will assist with alleviating the "cherry picking" of high-potential projects as occurred in PG&E's residential P4P programme.
- The value of P4P models that unlock energy efficiency is clear through increased system resilience, improved health outcomes and reduced consumer bills.

Source: Energy Trust of Oregon Residential Pay for Performance Pilot Evaluation Report (2021)

Description: The Energy Trust of Oregon implemented a residential Pay for Performance (P4P) pilot from April 2019 to December 2020. This source presents findings from an evaluation of the pilot that Apex Analytics conducted under contract to Energy Trust.

Comments:

- This scheme differs from a "pure" P4P scheme as participating contractors ("aggregators") were rewarded with an additional performance incentive for measured energy savings achieved above a deemed estimate. A "pure" P4P approach only utilises incentives which are based on measured energy savings. By continuing to pay deemed incentives, Energy Trust reduced the risk of participating in the pilot to the aggregators.
- The scheme expected energy savings may be increased by installing additional measures where deemed savings are not eligible, or by identifying and preferentially targeting projects with the greatest savings. The latter option could be deemed "cherry-picking" and is not favoured in many cases as public institutions are left with the least financially viable projects to support.

Market Segments and Use Cases Examined:

- US residential market, technology agnostic (participating "aggregators" included a HVAC contractor, a weatherisation contractor, and a whole house contractor.)

Key Takeaways:

- A lack of available data limited the size of resultant portfolios, with more than half of one aggregators initial portfolio determined to be ineligible due data issues such as insufficient baseline data.
- Measuring savings relative to deemed estimations ensured that issues with deemed savings, such as overestimation, were carried through to the pilot, resulting in metered savings which often fell short of estimates. This was particularly the case with ductless heat pump installations, which was attributed in part for additional utilisation of heat pumps for cooling or to displace secondary heat sources like wood stoves in cold months. The climatic conditions also limited the relevance of deemed estimations, particularly in climates which were relatively milder.
- Delayed performance payments must be carefully timed to create a feedback loop that influences positive market approaches. This feedback loop could be further improved where non-aggregator staff assess performance and provide recommendations for improvement.

Source: Pacific Gas & Electric NMEC Control Group Accuracy Assessment

Description: Pacific Gas & Electric (PG&E) currently uses the CalTRACK method to estimate all site-level energy efficiency savings for many of its programmes, including the Pay-forPerformance programme. Their method relies on whole-building granular electric or gas consumption data to estimate the savings associated with the installation of an individual or multiple energy efficiency measures at the site, with data usually sourced from automated meters, which have high regional penetration.

Comments:

- The source contains an assessment of how CalTrack responds to conditions arising from the COVID-19 pandemic.
- The assessment used synthetic control and difference-in-differences to cluster or disaggregate participant loads based on characteristics such as climate zone, solar status, usage etc. All control group methods outperformed methods without a

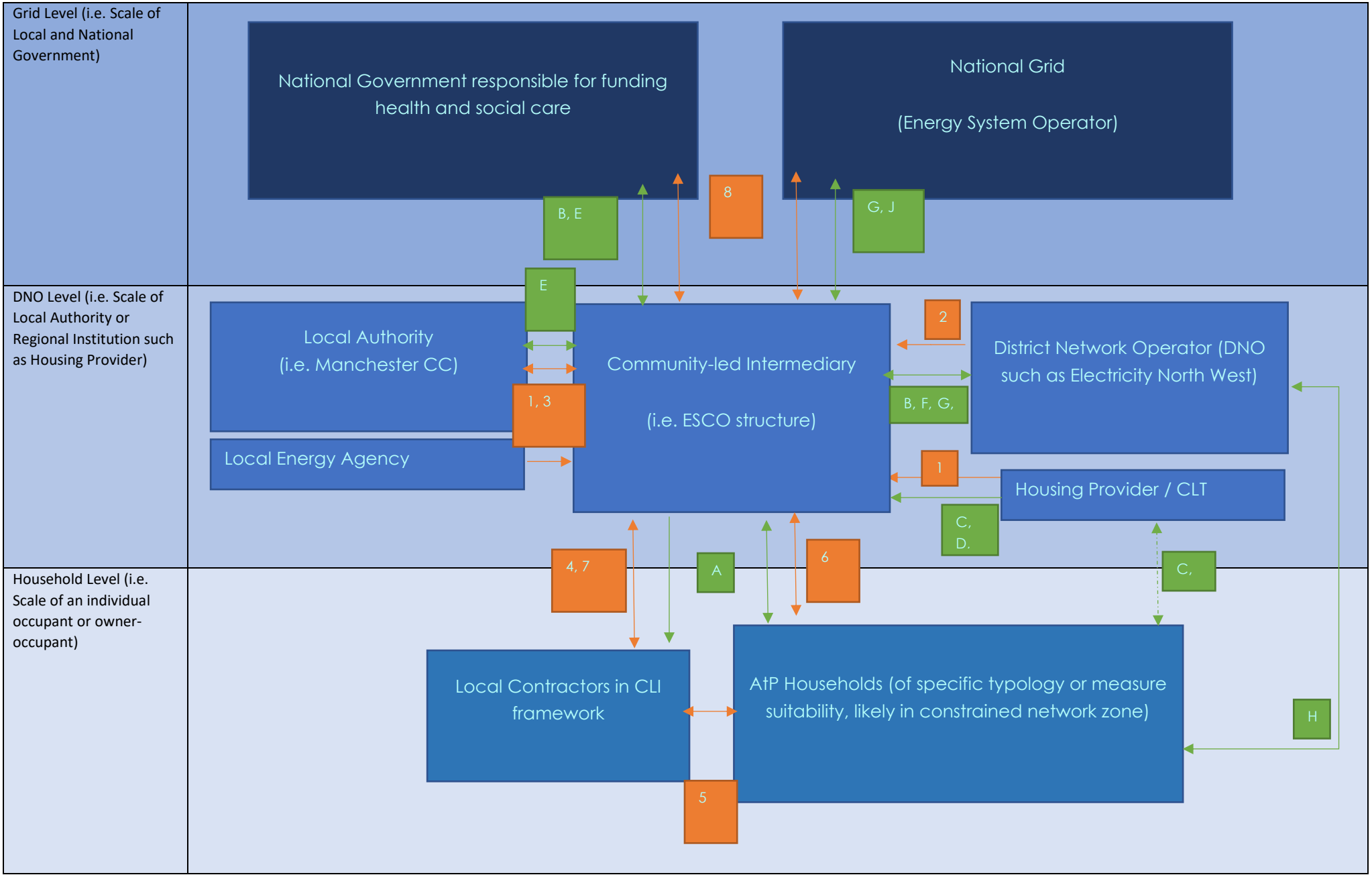
control group, with Difference-in-differences approaches outperforming CalTrack + Synthetic control.

Market Segments and Use Cases Examined:

- Normalised Metered Energy Consumption across the Californian market.

Key Takeaways:

- None of the CalTrack methods tested were able to overcome the effects of COVID on residential consumption profiles.
- Adding control groups improves accuracy and precision, with the best control group method dependent on the segmentation used.
- Divulgence of individual non-participant data can be avoided through use of granular profiles instead of individual matched controls, with comparable results.
- This programme was the only residential P4P programme running in the last few years (references to the scheme are scarce online, but validated in operation August 2022). 2023 budgets do reference other P4P schemes.
- The normalised metered energy consumption methods would be useful in multiple programmes alongside P4P schemes.



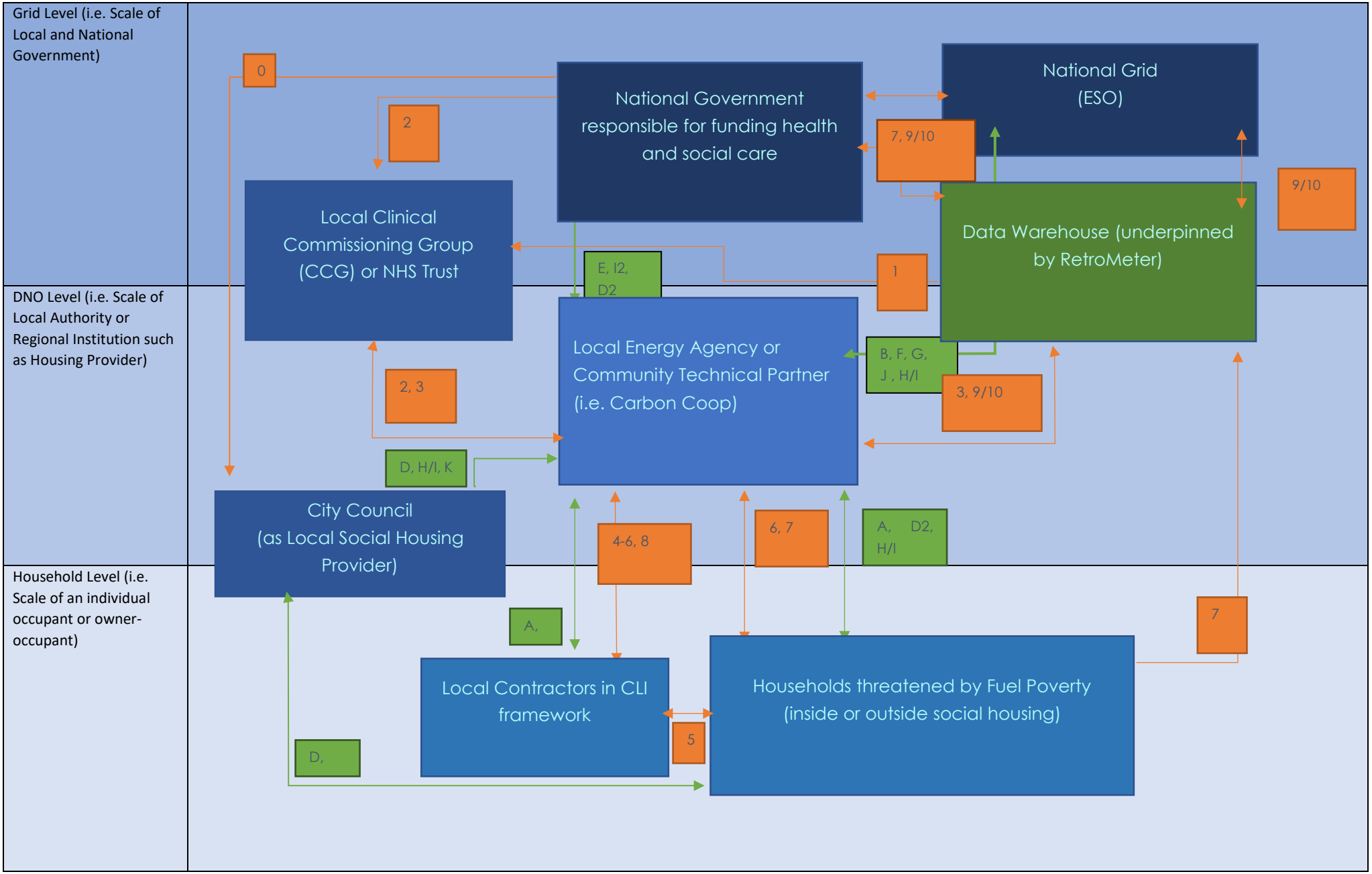

Permutation: Area based scheme involving Housing Provider with Measures providing both fast and slow flexibility

1) A local community-led intermediary (CLI) is established using an ESCO-like structure led by a combination of community energy organisations, LEPs, including one or more housing providers or community land trusts (CLT). This is likely developed with LA funding.
2) A DNO helps to identify constrained zones and peaks in the local load profile. The DNO also could codify the response rate, thresholds and key specification for any fast flexibility services. Slow flexibility services should be specified as a centralised scheme for the occupant to implement (i.e. Electricity North West Picoflex offer or Octopus' Saver Sessions). From here the CLI proposes and models the impacts of targeting specific building typologies or energy improvement measures, which are confirmed with the DNO. Through the alpha and beta phases the RetroMeter consortium should explore how DNOs value and measure permanent shifts in load and secondly, the extent to which fabric improvements open up further temporal flexibility around heating.
3) Error, uncertainty and performance thresholds are then codified by the CLI, and an underperformance compensation scheme developed to de-risk projects to an acceptable level for contractors, with costs born in part by the local authority.
4) Contractors develop quotes and performance estimations in response to the defined retrofit offer (based on a specific building typology/measure). These are accepted or rejected by the ESCO-like CLI. Whilst there are other approaches for procuring works (to be explored in the alpha phase), this approach offers more control over specifications and quality - which can be important factors in delivering performance.
5) Works commence and performance is "metered".
6) AtP households receive energy bill reductions, which are then shared in part with the ESCO who can use these alongside other datapoints to determine project performance
7) The contractor receives a performance-incentive payment. This may be minimal or born by the LA if the project underperformed.
8) Performance data at project and network levels are provided to DNOs and National Grid ESO. Information on health outcomes is derived or produced by National and Local Government, motivating further engagement or performance payments.
    a. Flexibility services are divided into Explicit services (with digital control systems operated by the intermediary or pre-set thresholds as agreed with owner/occupant) and Implicit flexibility (which is executed by the occupant as per octopus saver sessions model).
    b. Revenues C, D (capital gains/rental and EPC uplift) and revenues K, L (avoided connection charges and private infrastructure costs) are codified pre-project or following a yearly review of energy improvements.

| Value / Revenue Stream | Scale or Level of Benefit (Grid/DNO /Household) | Market Status | Valorised through: | Realised Through |
|---|---|---|---|---|
| Load Reduction (Energy cost savings) **[A]** | Household (Occupant) | Proven | Cost abatements; EPC; Shared Savings; Performance Bonus / Malus | RetroMeter |
| Identification of Non-Routine Consumption (underheating) **[B]** | Grid / DNO (Government responsible for health and social care and grid actors responsible for asset deployment). | Proven | Improvement of network forecasting and deployment of assets where most needed. Improved Social Prescribing avoids healthcare costs. | Data Warehouse |
| Increase in real estate / rental value (housing provider or community land trust only) **[C]** | Household or DNO (depending on whether Building Owner is occupant or landlord, with latter able to reinvest in wider stock at DNO level) | Proven | Capital Gains and Rental Agreements | Data Warehouse |
| EPC Uplift (housing provider or community land trust only) **[D]** | Building Owner (depending on whether Building Owner is occupant or landlord, with latter able to reinvest in wider stock) | Piloted | Performance Contracts | Data Warehouse |
| Emissions Reductions and Improved Environment (including Air Quality) **[E]** | DNO/Household (local government and occupant respectively) | Proven (ETS etc) | Emissions Trading/Insetting, Subsidies. Improved air quality / indoor environment avoids healthcare costs. | Data Warehouse |

| | | | | |
|---|---|---|---|---|
| Deferred Network Reinforcement (Load Reductions) **[F]** | DNO/Household (occupant benefits through reduced network charges on bill) | Piloted | Deferral of network reinforcement costs, Reduced need for load curtailment and expensive flexibility services. | RetroMeter and Data Warehouse |

| Value / Revenue Stream | Who Benefits / Pays? | Market Status | Valorised through: | Realised through: |
|---|---|---|---|---|
| Peak Capacity Uplift / Load Shaping (deferred network reinforcement) **[G]** | DNO / Household. (latter via reduced network costs.) | Proven | Arbitrage; Performance contracts (capacity margin KPI) | Data Warehouse |
| Provision of Implicit Flexibility (initiated by occupant, dependent for specific measures) **[H]** | DNO / Household. (latter via reduced network costs or flex. payments) | Proven | Performance Contracts / Reverse Auctions (reserve value KPI) | RetroMeter and Data Warehouse |
| Provision of Explicit Flexibility (initiated by building owner/operator, dependent for specific measures) **[I]** | DNO / Household. (latter via reduced network costs or flex. payments) | Proven | Performance Contracts / Reverse Auctions (reserve value KPI) | RetroMeter and Data Warehouse |
| Reduced Public Infrastructure Costs (i.e. increased cost effectiveness of deployed infrastructure) **[J]** | DNO / TNO. Consumers via network costs. | Unproven | Reduced Externalities (network charges) | Data Warehouse |
| Avoided demand / connection charges (only for housing providers / CLT) **[K]** | Building Owner / Occupant | Proven | Reduced demand charges. Reduced connection charges. | RetroMeter |
| Reduced private infrastructure costs (EVs / REG) (only for housing providers / CLT) **[L]** | Building Owner / Occupant | Piloted | Self consumption turn up (avoided import), Arbitrage. | RetroMeter and Data Warehouse |


Grid Level (i.e. Scale of Local and National Government)
DNO Level (i.e. Scale of Local Authority or Regional Institution such as Housing Provider)
Household Level (i.e. Scale of an individual occupant or owner-occupant)
0
2
National Government responsible for funding health and social care
National Grid (ESO)
7, 9/10
9/10
Local Clinical Commissioning Group (CCG) or NHS Trust
E, I2, D2
1
Data Warehouse (underpinned by RetroMeter)
Local Energy Agency or Community Technical Partner (i.e. Carbon Coop)
B, F, G, J , H/I
3, 9/10
2, 3
D, H/I, K
City Council (as Local Social Housing Provider)
4-6, 8
6, 7
A, D2, H/I
A,
7
Local Contractors in CLI framework
5
Households threatened by Fuel Poverty (inside or outside social housing)
D,

Permutation: Metered Social Benefits with Social Housing Decarbonisation Funding

0) Funding is allocated to the retrofit scheme through the SHDF model for the initial tranche of retrofit. This will define which other steps and value streams are relevant based on the "lots" and scheme approach produced by the LA and social housing provider. In addition, SHDF is driven by improvement of space heating demand to 90 kWh/$m^2$/yr and improvement of EPC ratings to band C, which may impact which properties are eligible for the initial tranche. Depending on the final market value of other revenue streams, the scheme may transition away from SHDF as "core" funding to support a wider segment of the housing stock.
1) If a data warehouse is available, summaries of project impacts on indoor environment quality and internal temperature changes (likely derived from heating system efficiency or heat transfer coefficient [HTC]) will be made available in order to help with quantifying the value of social prescription of building/energy improvements.
2) CCCG or local NHS trust establishes social prescribing programme / regime that outlies the target segment (geography, income range/ability to pay, EPC rating or description of indoor environment thresholds to trigger support). The viability of this step will be explored further in the alpha phase.
3) Local Energy Agency or Community Technical Partner (CTP) responds to social prescribing programme with a defined retrofit offer integrating specific building typologies or measures. This could be flexible to a range of measures that will satisfy an improvement of another KPI, such as HTC.
4) [Concentrated]: Contractors provide set quotes for the defined offer and market segment (i.e. pre-1930s tenement/terraced homes), providing cost and performance ranges that are ready to be deployed. The definition of performance ranges may also be led by the community technical partner depending on final scheme design.

a. [Distributed]: Community Technical Partner visits site and defines the "baseline" condition of the property (in particular relevance of historic data, comfort survey and heating-specific building fabric elements such as cavity/wall insulation, loft insulation, glazing, doors, airtightness and draughtiness, heating system, heating controls, tariff type etc). This should also include any description of the ideal "comfort" range for the occupants, i.e. 18 $^oC$ or 21 $^oC$ preferred temperature etc, plus number of rooms and occupancy profile if helpful.

   Contractors provide site-specific quotes in response to the "baseline" provided, or may accompany the CTP on site visits once qualified. This defines performance ranges or expected changes to KPIs such as HTC.

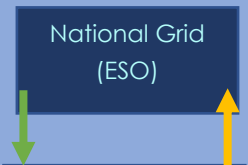
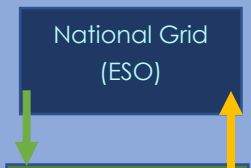
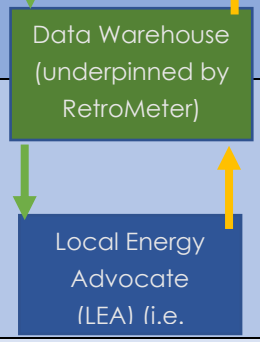
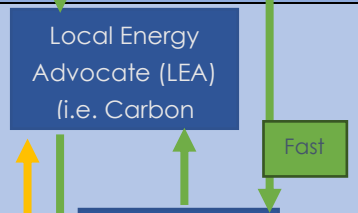
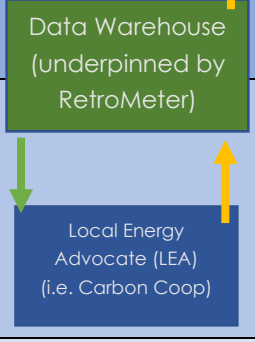
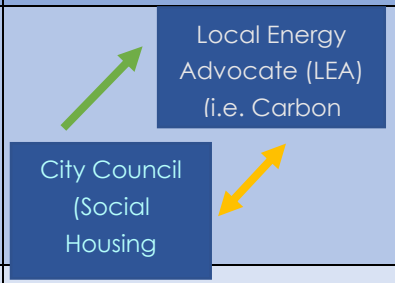
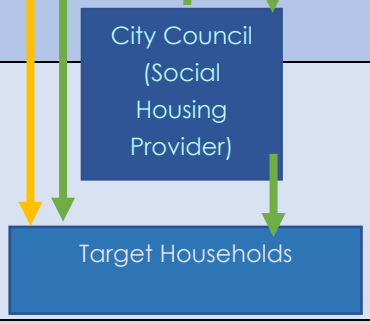
5) Retrofits are prescribed and the Community Technical Partner selects the most relevant quote based on the contractor's estimations and specifications of building performance improvements.
6) Works commence and performance is "metered".
7) Households receive a follow-up comfort survey and request for feedback alongside energy cost reductions/completion tests. Once data privacy and consent issues are resolved, energy consumption and any KPI/IEQ data can then be shared with the ESCO and related data warehouse who can use these alongside other datapoints and novel methods to determine project performance. National or local government then fund the maintenance and access of this warehouse.
8) The contractor receives a performance-incentive payment based on completion tests or numerical outputs. This may be minimal or avoided altogether if the project underperformed.
9) Performance data at project and network levels are provided to DNOs and National Grid ESO. Information on health outcomes is derived or produced by National and Local Government, motivating further engagement or performance payments.
10) Further pilot or public schemes are run in the housing segment, with RetroMeter enabling the M&V of these services. This could include additional payments to "maintain" the baseline and reporting period data.

| Value / Revenue Stream | Who Benefits / Pays? | Market Status (Proven, piloted, unproven) | Valorised through: | Realised Through |
|---|---|---|---|---|
| Load Reduction (Energy cost savings) **[A]** | Occupant | Proven | Cost abatements; EPC; Shared Savings; Performance Bonus / Malus | RetroMeter |
| Identification of Non-Routine Consumption (underheating) **[B]** | Owner / Occupant (depending on responsibility) | Proven | Improvement of network forecasting and deployment of assets where most needed | Data Warehouse |
| EPC Uplift (housing provider or community land trust only) **[D]** | Building Owner | Piloted | Performance Contracts | Data Warehouse |
| Comfort Improvements **[D2]** | Occupant | Piloted (Mbenefits and other R&D) | Enhanced Performance Contracts, Internal Processes. Improved indoor environment avoids healthcare costs | RetroMeter and Data Warehouse |
| Emissions Reductions and Improved Environment (including Air Quality) **[E]** | Occupant / Government. Local Public. | Proven (ETS etc) | Emissions Trading/Insetting, Subsidies. | Data Warehouse |
| Deferred Network Reinforcement (Load Reductions) **[F]** | Occupants via Network Charges | Piloted | Deferral of network reinforcement costs, Reduced need for load curtailment and expensive flexibility services. | RetroMeter and Data Warehouse |

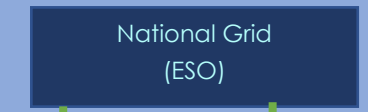
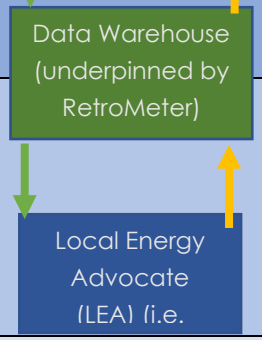
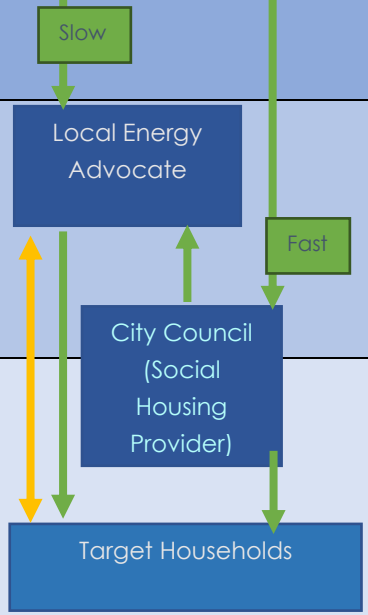
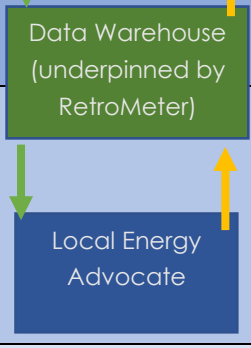
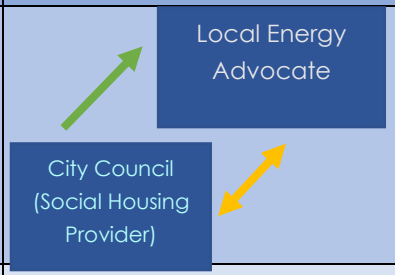
| Value / Revenue Stream | Who Benefits / Pays? | Market Status | Valorised through: | Realised through: |
|---|---|---|---|---|
| Peak Capacity Uplift / Load Shaping (deferred network reinforcement) **[G]** | DNO / TNO. Consumers via network costs. | Proven | Arbitrage; Performance contracts (capacity margin KPI) | Data Warehouse |
| Provision of Implicit Flexibility (initiated by occupant, dependent for specific measures) **[H]** | DNO / TNO. Consumers via network costs. | Proven | Performance Contracts / Reverse Auctions (reserve value KPI) | RetroMeter and Data Warehouse |
| Provision of Explicit Flexibility (initiated by building owner/operator, dependent for specific measures) **[I]** | DNO / TNO. Consumers via network costs. | Proven | Performance Contracts / Reverse Auctions (reserve value KPI) | RetroMeter and Data Warehouse |

| | | | | |
|---|---|---|---|---|
| Emissions/Air Quality Improvements (near power stations providing containment / capacity reserve) **[I2]** | Government. Local Public (local to power station, not project site) | Unproven | Reduced Externalities (costs of disability adjusted years lost, health care, climate adaptation / mitigation) | N/A |
| Reduced Public Infrastructure Costs **[J]** | DNO / TNO. Consumers via network costs. | Unproven | Reduced Externalities (network charges) | Data Warehouse |
| Avoided demand / connection charges **[K]** | Building Owner / Occupant | Proven | Reduced demand charges. Reduced connection charges. | RetroMeter |

| Revenue Stream for "Metered Social Benefits underpinned by SHDF" model | Load Reduction (Energy cost savings) [A] | Identification of Non-Routine Consumption (underheating) [B] | EPC Uplift (housing provider or community land trust only) [D] | Comfort Improvements [D2] | Emissions Reductions / Improved Environment (i.e. Air Quality) [E] | Deferred Network Reinforcement (Load Reductions) [F] |
|---|---|---|---|---|---|---|
| Grid Level (i.e. Scale of Local and National Government) | | National Grid (ESO) | | National Government (funding healthcare) | National Government (funding healthcare) | National Grid (ESO) |
| DNO Level (i.e. Scale of Local Authority or Regional Institution such as Housing Provider) | Local Energy Advocate (LEA) (i.e. Carbon Coop) | Data Warehouse (underpinned by RetroMeter)<br>Local Energy Advocate (LEA) (i.e. Carbon Coop) | Local Energy Advocate (LEA) (i.e. Carbon Coop)<br>City Council (Social Housing Provider) | Local Energy Advocate (LEA) (i.e. Carbon Coop) | Local Energy Advocate (LEA) (i.e. Carbon Coop) | Data Warehouse (underpinned by RetroMeter)<br>Local Energy Advocate (LEA) (i.e. Carbon Coop) |
| Household Level (i.e. Scale of an individual occupant or owner-occupant) | Target Household<br>Local Contract | Households threatened by Fuel | Local Contract<br>Target Households | Target Household | | |
| Narrative | Intervention returns are shared between target households and the LEA. The LEA reviews savings against contractor estimations and provides a bonus or malus depending on project performance. | Household smart meter data, analysed by the LEA, identifies likely underheating alongside the outcomes of retrofit. This insight into underheating and comfort takeback is shared with grid operators via a data warehouse in return for funding. | City councils invest in local contractors' delivery of retrofits. The LEA supervises the verification of Energy Performance Certificate uplift and passes on a performance payment to motivate quality delivery & verification. This will help with MEES compliance where relevant, but one should note there are major issues with EPC methodologies, particularly around electrification. | LEA delivers high quality projects that unlock and "measure" comfort takebacks, improving indoor environment and local health outcomes. Local or national government (or adjacent bodies) fund in return for verified data on project outcomes. | LEA delivers emissions reductions via retrofit, improving air quality and health outcomes (the scale of which will need investigation). Funding derived from emissions accounting (i.e. sale of credits or support for LA Net Zero transition.) | The impact of retrofit is quantified, particularly for KPIs such as peak capacity. Data is stored in a "warehouse" to be monetised by grid operators. This helps fund both retrofits & the data warehouse. |

| Revenue Stream: "Metered Social Benefits underpinned by SHDF" model | Peak Capacity Uplift / Load Shaping (deferred network reinforcement) [G] | Provision of Fast/ Slow Flexibility (technology dependent – not priority) [H] | Reduced Public Infrastructure Costs [J] | Avoided demand / connection charges [K] |
|---|---|---|---|---|
| Grid Level (i.e. Scale of Local and National Government) |  |  |  | |
| DNO Level (i.e. Scale of Local Authority or Regional Institution such as Housing Provider) |  |  |  |  |
| Household Level (i.e. Scale of an individual occupant or owner-occupant) | |  | | |
| Narrative | The impact of retrofit is quantified by the LEA, particularly for KPIs such as changes to load profile and "peak smoothing". Data is stored in a "warehouse" to be monetised by grid operators. This helps fund both retrofits & the data warehouse. | The LEA may develop retrofit offers which include assets providing fast or slow flexibility services to the grid, with RetroMeter verifying impact. Fast frequency services would be operated by the housing provider (i.e. city council for social housing), with revenues shared with the LEA/target household. Slow flexibility services flow through LEA to households. | The impact of retrofit is quantified by the LEA, particularly for modelling changes to occupant behaviour, rebound effects and load profiles. Data is stored in a "warehouse", which helps grid operators to deploy assets where needed most and with a view to future scenarios. This avoid costs which can be used to fund both retrofits & the data warehouse. | The LEA exchanges information with the city council or housing provider to identify where capacity / connection charges are highest and how retrofit will help alleviate these. The LEA then delivers and verifies abatements through specifications for local contractors, and shares the avoided costs from the city council to fund measurement and verification. |

| Revenue Stream<br><br>for Community-Led Intermediary Model (Area based scheme) | **Load Reduction**<br><br>*(energy cost savings)* | **Identification of Underheated Homes**<br><br>*(energy demand modelling)* | **EPC Uplift** | **Comfort Takeback**<br><br>*(avoided healthcare)* | **Reduced Emissions & Air Pollution** | **Deferred Network Reinforcement**<br><br>*(load reductions)* |
|---|---|---|---|---|---|---|
| **Grid Level** | | National Government (funding healthcare) | | National Government | National Government | National Grid (ESO) |
| **DNO Level** | Community-led Intermediary (i.e. community ESCo) | (Opt.) Local Clinical Commissioning<br>Community-led Intermediary | Community-led Intermediary | Community-led Intermediary | Community-led Intermediary | Data Warehouse (underpinned by RetroMeter)<br>Community-led Intermediary |
| **Household Level** | Target Household<br>Local Contract | Households threatened by Fuel | Housing Provider or Community Land Trust<br>Local Contract<br>Target Household | Target Household | | |
| Narrative | Intervention returns are shared between target households and the LEA. The LEA reviews savings against contractor estimations and provides a bonus or malus depending on project performance. | Household smart meter data, analysed by the LEA, identifies likely underheating alongside the indoor environment outcomes of retrofit. The avoided costs of health/social care fund this work via local NHS. | City councils invest in local contractors' delivery of retrofits. The LEA supervises the verification of EPC uplift and passes on a performance payment to motivate quality delivery & verification. | LEA delivers high quality projects that unlock and "measure" comfort takebacks, improving indoor environment and local health outcomes. Government funds in return for verified data on project outcomes. | LEA delivers emissions reductions via retrofit, improving air quality and health outcomes. Funding derived from emissions accounting (i.e. sale of credits or support for LA Net Zero transition.) | The impact of retrofit is quantified, particularly for KPIs such as peak capacity. Data is stored in a "warehouse" to be monetised by grid operators. This helps fund both retrofits & the data warehouse. |

| Revenue Stream for Community-Led Intermediary Model (Area based scheme) | **Peak Capacity Uplift / Load Shaping** *(deferred network reinforcement)* | **Provision of Fast / Slow Flexibility** *(technology dependent)* | **Reduced Public Infrastructure Costs** | **Avoided demand / connection charges** |
|---|---|---|---|---|
| **Grid Level** |  |  |  | |
| **DNO Level** |  |  |  |  |
| **Household Level** | | | | |
| Narrative | The impact of retrofit is quantified by the LEA, particularly for KPIs such as changes to load profile and "peak smoothing". Data is stored in a "warehouse" to be monetised by grid operators. This helps fund both retrofits & the data warehouse. | The LEA may develop retrofit offers which include assets providing fast or slow flexibility services to the grid, with RetroMeter verifying impact. Fast frequency services would be operated by the housing provider (i.e. city council for social housing), with revenues shared with the LEA/target household. Slow flexibility services flow through LEA to households. | The impact of retrofit is quantified by the LEA, particularly for modelling changes to occupant behaviour, rebound effects and load profiles. Data is stored in a "warehouse", which helps grid operators to deploy assets where needed most and with a view to future scenarios. This avoid costs which can be used to fund both retrofits & the data warehouse. | The LEA exchanges information with the city council or housing provider to identify where capacity / connection charges are highest and how retrofit will help alleviate these. The LEA then delivers and verifies abatements through specifications for local contractors, and shares the avoided costs from the city council to fund measurement and verification. |

| Asset Type | Measure | Cost | Minimum Cost per kW / kVA | Cost per Home (assumed 200 homes per substation) | Notes |
|---|---|---|---|---|---|
| LV Main overhead line | per metre | £17.72 | - | - | |
| LV Main underground | per metre | £138.80 | - | - | |
| LV Service | each | £1,903.72 | - | - | |
| 6.6/11kV Transformer (Pole Mounted) | each | £4,468.09 | £14.18 | £22.34 | Assumed 315 kVA rating from this source: https://www.northernpowergrid.com/sites/default/files/assets/877.pdf |
| 6.6/11kV Transformer (Ground Mounted) < 500kVA | each | £18,193.27 | £36.46 | £90.97 | |
| 6.6/11kV Transformer (Ground Mounted) >= 500 & < 750kVA | each | £22,905.24 | £30.58 | £114.53 | |
| 6.6/11kV Transformer (Ground Mounted) >= 750kVA | each | £30,281.32 | £40.32 | £151.41 | |

# References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