Metered Energy Savings:

Briefing note for investors in domestic energy efficiency interventions and retrofit

Introduction

There is growing recognition of the need to retrofit both residential and non-residential buildings at scale to meet the UK's net zero targets. There are, however, many barriers to financing retrofit, particularly in the domestic market. The idea of metering energy savings is being adopted in the USA and can potentially make energy efficiency more investable by actually measuring real performance using a commonly defined measure of an energy saving. This paper describes the RetroMeter project, an Ofgem Strategic Innovation Fund project that aims to develop a metered energy savings methodology for the UK.

What are metered energy savings from retrofit ?

Traditionally energy efficiency projects are assessed on deemed savings, essentially an estimate of how much energy savings are expected based on engineering-based calculations for the measures installed (for example the level of insulation, or LED lamps). It is widely recognised that there is a 'performance gap' between projected savings and actual savings, which represents a barrier to confidence amongst consumers, and a risk to the investors in projects, whether they be individual consumers, corporates, or financial institutions.

In contrast to deemed savings, metered energy savings (MES) look at the actual metered energy use (metered gas and metered electricity) after the retrofit, and compare it to what energy would have been consumed in that home during the post-retrofit period, had there not been a retrofit, i.e. a "counterfactual" energy use.

MES emerged in California over the last decade and is now being used by utilities and regulators in several US states. The main use cases are: a) evaluating the effectiveness of energy efficiency subsidy programmes b) measuring the effect of various interventions on the load curves of utilities and c) being the standard 'weights and measures' of a market place for energy efficiency and flexibility.

What is the RetroMeter project?

The RetroMeter project aims to design and pilot metered energy savings in the UK context. The RetroMeter project is being led by Electricity North West in collaboration with Energy Systems Catapult, EnergyPro Ltd, Carbon Co-op and Manchester City Council, with funding through the Strategic Innovation Fund of the Office of Gas and Electricity Markets (Ofgem). The alpha phase of the project ran from October 2023 to March 2024.

What are the benefits of metered energy savings?

Retrofit evaluation and consumer protection: MES can contribute as part of an overall retrofit evaluation by verifying whether a retrofit has achieved what the householder and other stakeholders wanted it to achieve. MES can also facilitate and assure high-quality retrofits by holding actors in the retrofit supply chain accountable for the outcome of their work, using relatively few data points in a non-intrusive way.

Energy system planning: MES can contribute to learning and research about the real-life performance of retrofits, in terms of what types of retrofit measures work best in which situations. MES can help in the planning of our future energy system by estimating how much energy will likely be required when large numbers of households transition to more insulated homes – information which is useful both for households and the wider energy grid.

Leveraging finance for retrofit: MES can help to leverage financing for retrofit, by providing more confidence in the energy savings that underpin returns for private sector investment, and additional certainty of measured outcomes for public sector funders. This enables funders to pay for the performance and measurable value they receive from a series of retrofit projects, facilitating further collaboration and allowing new “pay-for–performance" business models to emerge.

How are Metered Energy Savings relevant for energy efficiency financiers / investors?

Metered Energy Savings and energy efficiency are relevant to financiers because:

- Energy efficiency represents a large potential market.
- Improving efficiency reduces risks in two ways:
    - By improving the cash flow of clients, thus reducing their risk.
    - By reducing the risk of financing assets becoming stranded as energy efficiency regulations are tightened. For example, tightening Minimum Energy Performance Standards exposes owners to the risk of owning an asset that cannot be sold or rented in future.
- Improving energy efficiency has a direct impact on reducing emissions of carbon dioxide and other environmental impacts such as local air pollution and therefore can be a key part of Environmental, Social and Governance (ESG) programmes.
- Bank regulators are increasingly requiring institutions to estimate and disclose climate-related risks and energy efficiency can reduce risks.

Despite this growing interest there are many barriers to scaling investment in energy efficiency, which predominantly exist due to the lack of performance data.

What types of households / retrofits could RetroMeter metered energy savings methodologies be applied to?

The work of Energy Systems Catapult under RetroMeter has primarily been focused on situations where metered gas is used pre-retrofit as the main heating source and a smart meter has been in place for at least a year before the retrofit. This gas data has been used to develop counterfactuals for how much gas the household would have consumed in the post-retrofit period, had the retrofit interventions not taken place. This counterfactual can be compared to the actual usage of gas post-retrofit.

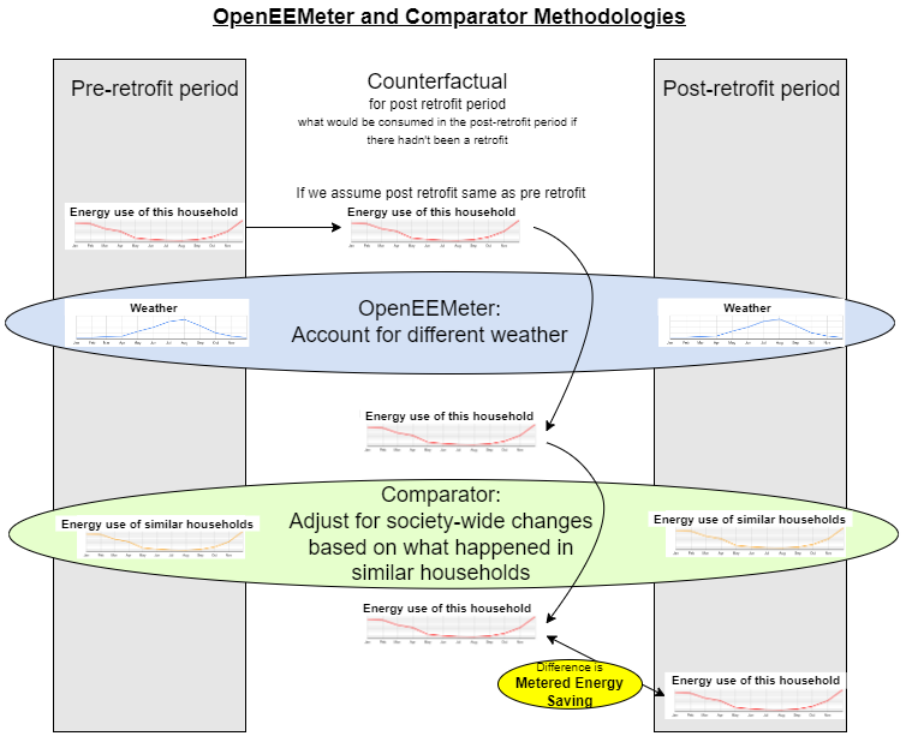
If the household has switched to electric heating (e.g. a heat pump) as part of the retrofit, the counterfactual gas usage can be compared with the actual electric heating consumption post-retrofit, but only if sub-metered data for the electric heating consumption is available.

While internal temperature data is not required for implementing two of the methodologies explored in this project, if temperature sensors are installed in the home post-retrofit, this can facilitate use of the additional physics-based methodology.

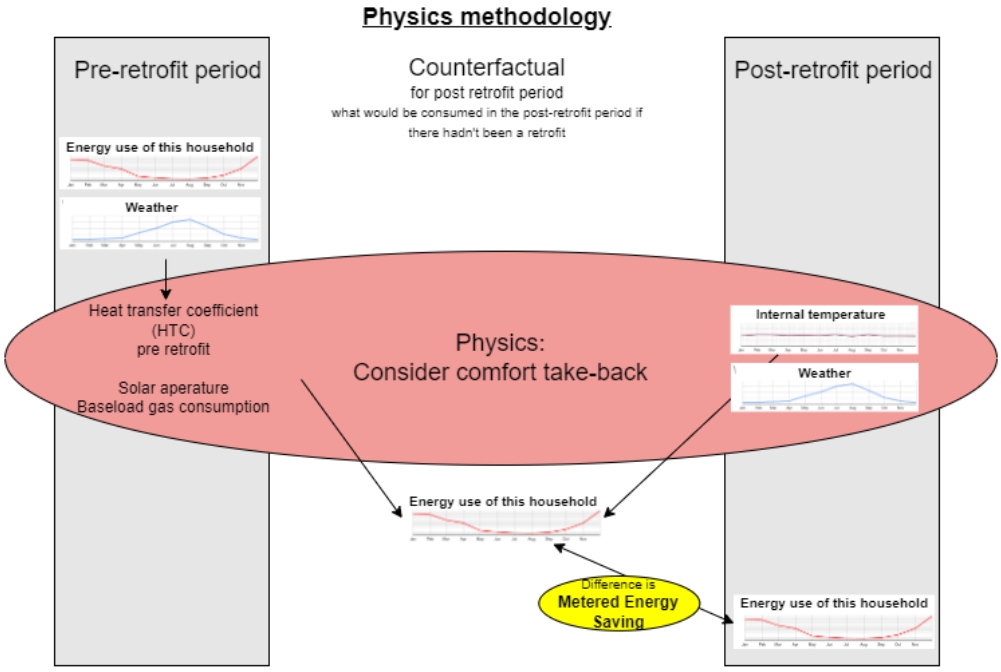
What are the methodologies being tested under RetroMeter?

The Energy Systems Catapult has tested three approaches to metering energy savings in this project:

1. **OpenEEMeter**: using the US OpenEEMeter, which is used in US programmes, on an 'as is' basis i.e. out of the box
2. The **comparator methodology** builds further on OpenEEmeter by comparing the energy use in the 'candidate' household post-retrofit, to energy use in the same period for similar households which have not had a retrofit. This can help separate out the energy changes due to retrofit from the energy changes happening in society more broadly. There are different ways of finding similar 'comparator' households - matching can be done based on:
    - **Property archetypes** – candidate and comparator households having the same built form, property type, property age, Energy Performance Certificate rating, and other qualitative factors;
    - **Total energy consumption during the baseline period** – grouping households into quantiles based on their total annual energy consumption, and matching candidate households with comparators in the same category; or
    - **Energy consumption profile similarity** – comparing the gas meter time series during the baseline period of the candidate household with the profiles of the comparator households directly in the same period.



3. The **physics-based methodology** uses internal temperature data post-retrofit and accounts for "comfort take-back". The physics-based methodology examines what energy households would have consumed in the post-retrofit period to achieve the internal temperatures they had in the post-retrofit period, if they still had their pre-retrofit Heat Transfer Coefficient (HTC).



The most accurate methodology tested by ESC was the comparator-methodology, when matching houses on energy consumption profiles.

		Accuracy Median CVRMSE on annual basis for individual household *Lower number means better accuracy*	Bias *Close to zero means less bias*
	OpenEEmeter – accounting for changes in weather	19%	17%
	Comparator methodology – matching households on archetypes	18%	-3.9%
	Comparator methodology – matching households on average energy consumption	15%	0.01%
Best result ->	**Comparator methodology** – matching on energy consumption profile	9.4%	0.01%
	Physics methodology – accounting for comfort take back	26% (using co–heating HTC) 33% (using modelled HTC) (note: monthly not annual)	0.7%

How applicable are metered energy savings at the individual household level versus aggregated across larger numbers of households?

While the lowest error is 9% at the individual household level, aggregating data to a 25-property portfolio successfully reduces the error to as little as 5% at the annual level, however it comes with some practical caveats that end-users must be aware of:

- The candidate properties within the portfolio must have had their interventions completed at around the same time, so that their baseline and reporting periods line up. This is necessary for ensuring that each property is fully represented at each timestep of the aggregated reporting period.
- They must also be sufficiently physically close to each other so that the same external temperature readings can be applied to each.
- MES cannot be disaggregated and attributed to individual properties with this approach.

These limitations imply that the portfolio aggregation approach is best suited to cases where a group of properties, managed by the same owner and on a single estate or terrace for example, can be retrofitted at the same time, and tied to a monitoring mechanism this is satisfied with attributing the MES to the project as a whole rather than individual properties.

How much does the accuracy of the methodologies affect the financial returns?

Whilst an in-depth sensitivity analysis around the effect of the methodology on the financial returns has not been undertaken in this phase of work, it is clear that accurate metering and measurement are crucial for verifying that the predicted energy savings are being achieved. If the baseline is inaccurately determined, it can lead to overestimation or underestimation of energy savings. Overestimation may result in unrealistic financial projections, while underestimation may lead to dissatisfaction among stakeholders. However, one must recognise the trade-off between the additional costs that metering and measurement leverage on project financials and the additional assurances and accuracy that these services provide. There will often be a "sweet spot" between the additional transaction costs of methodology improvements and the additional verification of project performance on which impact-based revenues are derived.

The requirements for an accurate energy savings estimation will directly impact the type of financial packages that could be offered towards an MES-enabled retrofit scheme.

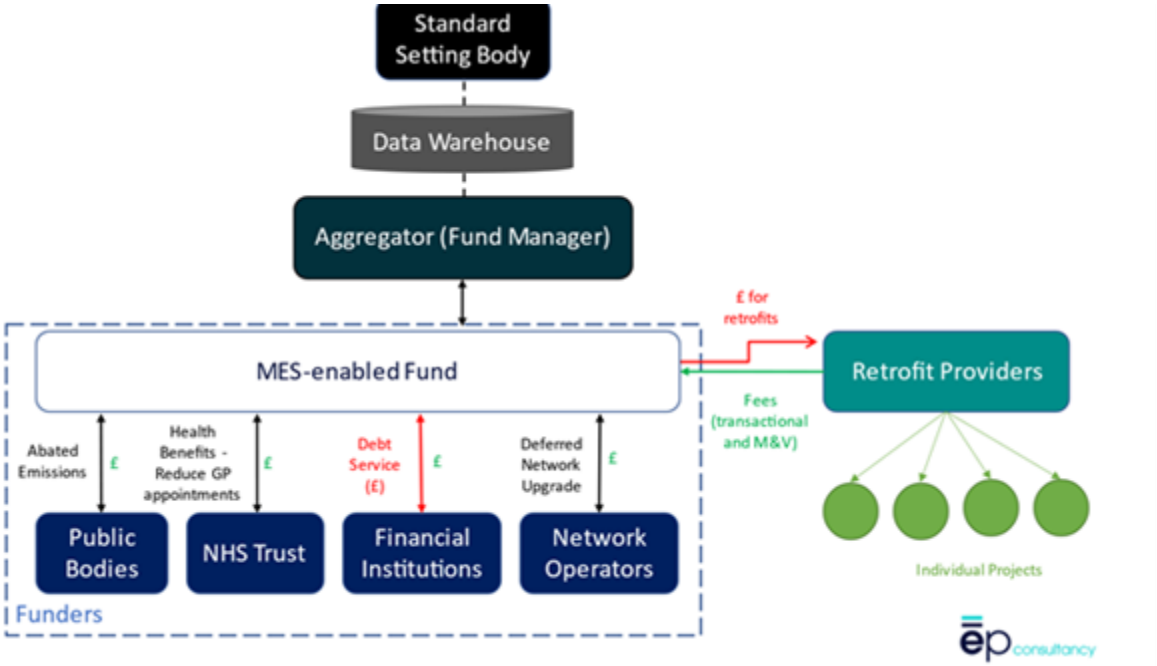
Two key factors affecting the accuracy of the MES methodology developed during this phase of work will affect the financial models:

- Number of Household Aggregations: The methodology is more accurate when aggregating 10s of houses at a portfolio level. This means financial models may need to focus on aggregated offerings.
- Time Aggregations: The methodology is more accurate at reporting monthly or annual energy savings compared to daily ones. Hourly energy savings are currently too inaccurate to introduce to the market. This means financial models will need to focus on verifying long-term benefits wherever possible.

In order to ensure the methodology does not over- or underestimate savings, financial models will need to focus on aggregated householder offerings and verifying monthly or annual energy savings. This may limit the opportunities to unlock explicit and implicit flexibility incentives from the network, quantify the emissions reductions at peak load times or identify non-routine consumption (underheating).

What sort of business models could leverage metered energy savings ?

MES could help to unlock a blended finance model which could provide benefits for NHS Trusts, financial institutions, network operators, householders, retrofit providers / facilitators and public bodies, amongst others. In order to align the strategic goals of the different stakeholders and leverage the impact of MES for residential retrofits at scale, an aggregator business model has been identified.



Under this model, the aggregator acts as a Fund Manager for a MES Fund, developing standardised guidance, data connections and project evaluation infrastructure centrally, which can replicated across multiple retrofit providers to apply for financing through the fund. A fund type structure is preferred due to the high transaction costs of arranging individual, blended financings using private capital seeking a financial return and outcomes based capital.

What are possible ways forward for piloting metered energy savings ?

This phase of RetroMeter has laid the groundwork for securing the data required to run a Metered Energy Savings calculation in two different retrofit delivery models. This includes a community intermediary led Area Based Scheme (by Carbon Co-op) and a strand of Social Housing Decarbonisation Funding (SHDF) delivered by Manchester City Council. The project compiled learnings and best practices around engagement with the various stakeholders implementing these schemes, engagement with parties who can facilitate access to internal environment (e.g. temperature) data, engagement with households on consent to smart meter data sharing, and software-based mechanisms for smart meter data sharing for MES. The next step is to test these mechanisms and run the calculations in real world delivery settings.

As a result of this project we now understand in much more detail the context of these delivery models, and the points at which a Metered Energy Savings methodology and approach will need to be integrated. We expect this to generate even richer insight into the effectiveness of messaging with householders and how Metered Energy Savings calculations can enhance the experience and understanding of Retrofit Providers and their partners.

While there are longer term goals of a standardised protocol and financial mechanisms underpinned by Metered Energy Savings calculations, in the short-term, piloting efforts would be wise to focus on testing and smoothing data access and data quality issues.

There will be ‘no one size fits all’ in engaging households, nor one defined route to accessing the data points required. This requires flexibility in approach, and significant efforts in the early-stage planning of projects. Much of this work is around relationship building and stakeholder engagement.

Conclusions

The use of MES could make energy efficiency more investable by financial institutions by enabling pay for performance business models and reporting of real, measured impacts. As such it is worthy of further research and development, including full-scale trials in domestic and non-domestic buildings and portfolios.

Further development of the MES concept in the UK will require a larger coalition of stakeholders including: government; Ofgem; DNOs; the ESO; the DCC; energy suppliers, the energy efficiency and flexibility industry; and very importantly financial institutions interested in increasing investment into decarbonisation.