Metered Energy Savings:

Briefing from RetroMeter project for Retrofit Providers, including housing providers and local authorities

What are metered energy savings from retrofit?

Deemed energy savings (for example, a change in Energy Performance Certificate (EPC) after energy saving interventions such as retrofit) involve estimating how much energy savings are expected based on the measures installed (for example the level of insulation), and how those measures are predicted to perform based on engineering-based calculations and laboratory testing.

On the other hand, 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.

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 retrofit providers?

Retrofit providers can benefit from MES as a way of demonstrating the quality and impact of their work, thereby generating increased confidence from households, landlords and finance providers. Deemed approaches to determining energy savings (such as determining a change in the Energy Performance Certificate (EPC) of a home based on measures installed) do not account for the quality of the design or of the installation of the measures. Using a MES approach, it is possible to examine whether the design and installation of the measures have actually achieved energy savings. This can lead to learnings about quality of design and installation and the real-life performance of retrofits in different real-life situations which can help retrofit providers improve the quality of their service over time.

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 types of households / retrofits could RetroMeter 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 is being 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.

If we're only interested in the total energy saved due to the heat pump and fabric retrofit, the comparison can be done on a simple energy basis. The process is a little more involved if the energy savings from fabric measures need to be disaggregated from the heat pump.

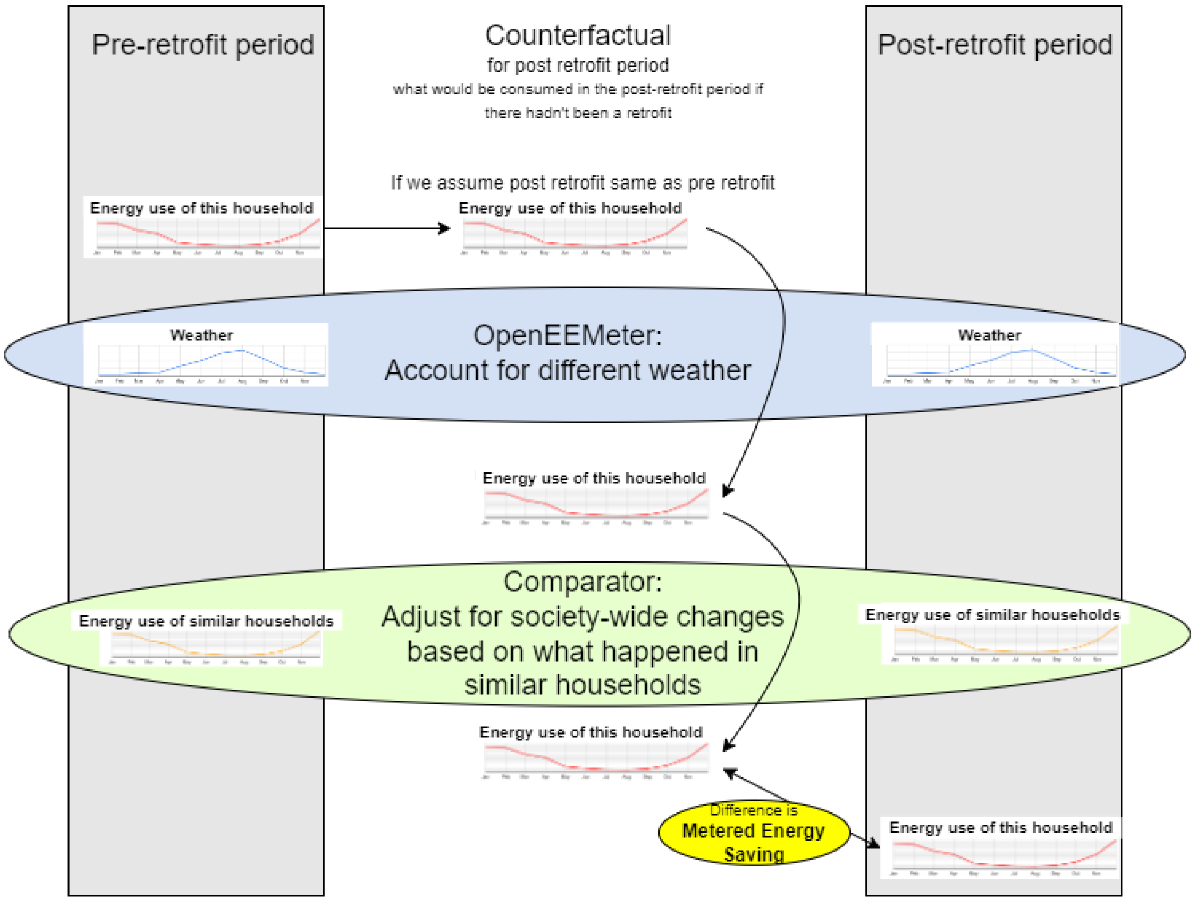
While internal temperature data is not required for implementing two of the methodologies explored in this project, if temperature sensors are installed in the home post-retrofit, this can facilitate use of the additional physics-based methodology.

What are the methodologies being tested under RetroMeter?

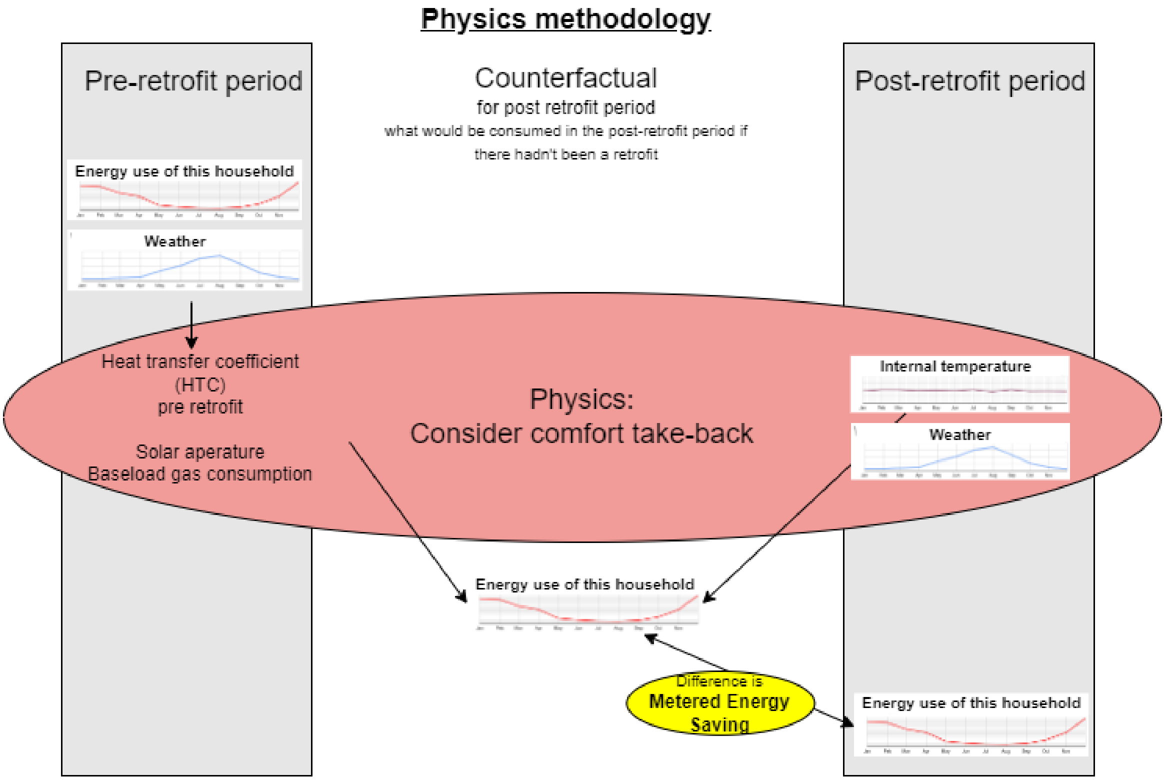
The project tested three methodologies:

1. **OpenEEmeter** (formally CalTRACK) is an MES methodology which began in California, United States and is currently maintained by the Linux Foundation. It accounts for the impact of weather on energy consumption using mean hourly external temperature and metered energy consumption in the pre-retrofit 'baseline' period, to fit regression models that also account for seasonal and other calendar effects. The most advanced version of this model does this on a daily basis, generating a counterfactual each day for what the energy use would have been given the weather conditions.
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.

OpenEEMeter and Comparator Methodologies



3. The **physics-based methodology** developed in RetroMeter uses internal temperature data post-retrofit and accounts for "comfort take-back" (households heating their home at a higher temperature post-retrofit because of increased affordability). 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). HTC is a measure of the rate at which the heat generated in a home is typically lost out of the home through heat leakage. For modelled HTC, the pre-retrofit HTC is estimated by correlating the pre-retrofit weather with the pre-retrofit gas usage. Co-heating HTC (generated by other sources) can be used instead of modelled HTC. The model looks at both gas and electricity usage, as it assumes that a certain proportion of electricity usage generates heat in the home indirectly (electric cooking and kitchen appliances, electronics, lights). The model accounts for solar aperture estimated using weather data (external temperature, solar irradiance) and pre-retrofit gas usage. The model also accounts for baseload gas usage (i.e. gas used for other purposes than space heating and water heating and cooking – this is calculated by looking at gas usage during warm weather in the pre-retrofit period). The model also makes assumptions about boiler efficiency being an industry average.



How accurate are the methodologies?

This project made use of anonymised metered gas data from Hildebrand, a smart meter data provider. Data from 2021-22 was used to generate a counterfactual energy use for 2022-23, and assuming that no retrofit was performed in these households, if the models were perfect, the generated counterfactuals should match the actual metered data for 2022-23. The testing work examines how closely they align, providing an indicator of the accuracy of the modelling approach in real-world settings.

The results of this testing so far are evaluated in terms of:

- **Bias** – whether the reporting period predicted gas consumption is, on average, higher or lower than the metered consumption;
- **Accuracy** – how much the reporting period predicted and metered gas consumption differ, in either direction. This accuracy can be aggregated at daily, monthly or annual levels. Accuracy is measured using a statistic called the Coefficient of Variation of Root Mean Squared Error (CVRMSE), where a high CVRMSE indicates poor accuracy.

The results of the testing are summarized in the table below.

		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%

In summary, these results show that the best approach is to use the comparator methodology, matching households on average energy consumption profiles.

How applicable are the methodologies at individual household level vs 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.

What are the data requirements?

Data from retrofitted/intervention households

To use the OpenEEMeter methodology, the following information is needed about the household where the intervention (such as retrofit) has taken place:

Methodology	Data/information needed	Pre-retrofit	Post-retrofit
OpenEEMeter and comparator methodologies	**Retrofit dates** - start and end date	✓	
	Household location (derived from postcode) so weather data can be retrieved	✓	
	External temperature at location (extracted from weather data sources using location)	✓ One year	✓ Best results with at least a year
	Smart meter data - gas	✓ One year	✓ Best results with at least a year
	Sub-metered electric heating (heat pump) data (if household moved from gas to electric heating (e.g. heat pump) as part of retrofit)		✓ Best results with at least a year
Physics based methodology - all the above plus:	Solar irradiance at location (extracted from weather data sources using location)	✓ One year	✓ At least one month winter data
	Internal temperature data		✓ At least one month winter data
	Smart meter data - electricity		✓ At least one month winter data

"Non routine events" are defined as changes in normal occupancy and major changes in appliances installed which will affect energy usage significantly (e.g. change in heating system, change from gas to electric cooker). Information about and dates of non-routine events can be used in order to establish whether certain periods of data for certain households should be excluded from analysis.

In summary, the data sets of interest are:

- **Smart meter data** – this can be obtained through a smart meter data sharing consent process from the household. It means the household must have had a smart meter installed at least a year before the intervention.
- **Sub-metered electric heating (e.g. heat pump) data** – this can be obtained through heat pump operating systems, with the consent of the household
- **Internal temperature data (optional)** – this can be captured through installing sensors in the home post-retrofit, and transmitting the data in real time or capturing the data in data loggers for later collection.

There are challenges with smart meter data availability, access and quality in the Great Britian context.

- **Availability**: Recent smart meter reports for Great Britian indicate ~61% of all domestic meters are smart meters[1]. However, 16% of gas smart meters are operating in 'traditional mode' (i.e not providing data to the smart metering network)[2]. Further meter outages are projected with over 20% of current smart meters due to lose communications as a result of the switch off of 2G and 3G mobile communications networks, requiring the installation of new communications modules.[3]

- **Quality**: Research done with the Smart Energy Research Lab (SERL) dataset has revealed significant data quality issues in terms of missing data at the half-hourly level.[4]
- **Accessibility**: In Great Britain smart meter data is owned by the consumer and governed by the General Data Protection Regulation (GDPR) and the Smart Energy Code (SEC) as private data. While the 2021's Energy Digitalisation Taskforce report recommended "developing a customer consent dashboard to help consumers understand who has access to their energy data, and why – building trust and consumer protection", we remain some way from this goal, with no common standard for how users access their data or manage consent for others to access their data.

Data from comparator households

To use the comparator-based methodology, with matching based on energy consumption profile, no additional data from the intervention household is needed. However, smart meter gas data from comparison groups of non-retrofitted households are needed.

Non-retrofit gas heated households could sign up to consent the use of their individual gas smart meter data for the purposes of serving as a comparison group. However, it is questionable whether a large enough group of non-retrofitted households would have interest in doing so.

Organisations who have access to gas smart meter data include gas suppliers, Data Communications Company (DCC), Hildebrand, N3RGY and research institutions such as University College London's Smart Energy Research Lab (SERL). Such institutions could make data available in a form which is aggregated across households, which allays privacy concerns.

- If matching on average consumption approach (less accurate): Organisations with access to this data could publish aggregated data (on an ongoing basis) of typical daily consumption of households which fall within certain total consumption bands (for example daily consumption values of households with low total consumption, daily consumption values of households with medium total consumption etc.).
- If matching on consumption profile approach (more accurate): A mechanism whereby an organisation with access to gas smart meter data provides a "comparison matching service" using code developed by the RetroMeter project. In this scenario, any party wanting to evaluate a retrofitted home would submit the retrofitted home's pre-retrofit gas data to the service, the service would run the code to find matching non-retrofitted households, aggregate these, and share the results back to the evaluating party.

[1] Smart Meter Statistics in Great Britain: Quarterly Report to end December 2023, OGL.
[2] Smart meters in Great Britain, quarterly update December 2023: statistical bulletin
[3] Update on the rollout of smart meters, Committee of Public Accounts, Oct 2023.
[4] Energies 2021, 14(21), 6934; https://doi.org/10.3390/en14216934

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.

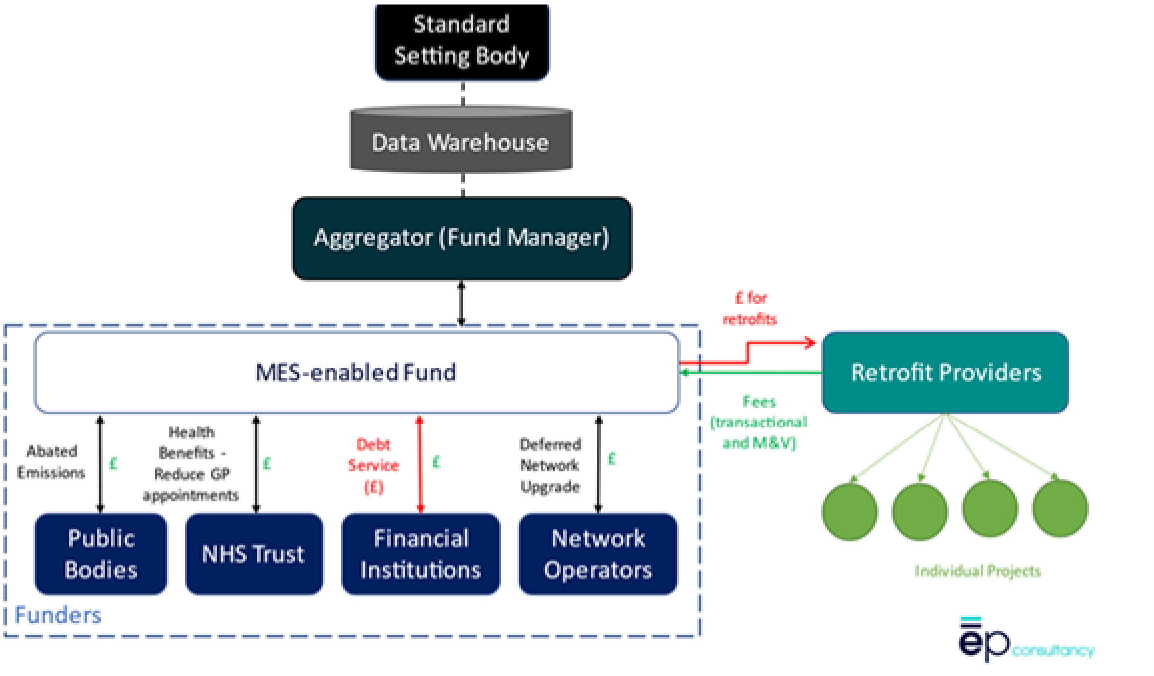
As a result of this project we now understand in much more detail the context of these delivery models, and the points at which a Metered Energy Savings methodology and approach will need to be integrated. We expect this to generate even richer insight into the effectiveness of messaging with householders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

It is clear that 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, to ensure that both householder facing and 'back office' roles understand the requirements and how it can benefit their work. Understanding how Metered Energy Savings can be integrated within broader retrofit and evaluation standards frameworks will also be a worthwhile focus in scaling the approach.

What sort of business models could leverage metered energy savings?

MES could help to unlock 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 be replicated across multiple retrofit providers to apply for financing through the fund. This will reduce the transactional and capital costs associated with ad hoc retrofit schemes, and ensure schemes are de-risked and quality-assured, unlocking massive investment into UK retrofit.

Way forward for metered energy savings in the UK

New collaborations and funding opportunities are currently being explored to put in place mechanisms for access to comparison group data for MES, to refine, finalise and standardise MES methodology, and to pilot MES in a variety of settings, schemes and types of households.