Green Finance Institute: Coalition for the Energy Efficiency of Buildings

Towards a protocol for metered energy savings in UK buildings

Authors
Alex Rathmell, Tadj Oreszczyn, Juliet Phillips, Sam Thomas, Chris Jofeh

With special thanks to Andy Sutton, George Simms, ENSMOV, SENSEI projects and Recurve Analytics

Executive summary

This report compiles the findings and recommendations of the Green Finance Institute's Coalition for the Energy Efficiency of Buildings (CEEB) to establish a standardised, industry-recognised protocol to 'meter' energy savings in UK buildings. The protocol seeks to provide actionable data and real-time performance monitoring to create confidence and certainty around retrofit performance. This will enable new forms of contracting and procurement between energy utilities, networks and aggregators of energy efficiency projects, and will underpin the new financial products and business models that will deliver energy efficiency retrofits at scale, reducing emissions, creating warmer homes and lowering bills.

The report outlines the background and mission of the CEEB, before introducing the concept of metered energy savings. It examines specific considerations about capturing metered energy savings in the UK, outlines the various stakeholders that might use this, and the different business models it could support. It then presents the Working Group's proposed protocol, setting out the data inputs that are essential and highly desirable to be included within this methodology. The CEEB welcomes feedback on this technical proposal.

Summary of recommendations

- There is a need for a standardised method for evaluating the performance of retrofit projects in terms of the energy saved and the outcomes delivered, based on building-specific, measured data. Such a method would provide certainty to householders, retrofit solution providers, funders (whether on a programmatic basis, or via new financial products) and energy networks on the energy and cost savings achieved by a project.

- Energy savings in UK buildings can be 'measured' by creating an industry-standard protocol to calculate a counterfactual baseline – the estimated amount of energy that would have been used in a specific building had an energy efficiency retrofit not taken place. Actual energy use after the retrofit is then compared against this baseline in order to quantify – or 'meter' – the amount of energy use avoided.

- The baseline calculation should take into account key variables that influence a building's energy consumption, including outdoor temperature and building occupancy, so that the impact of the retrofit can be separated from these other factors.

- The protocol should verify the quality of the building's indoor environment after the retrofit by measuring average indoor temperature, CO_2 concentration and relative humidity.

- A specific emissions (CO_2e) saving, or energy use avoidance calculation, should be incorporated into the protocol.

- Calculations should be carried out in cloud-based software.

- Customer energy data should be carefully managed and protected, in line with industry privacy regulations and established best practices.

- The protocol should be open source and designed for ubiquitous use, so that retrofit professionals can integrate metered energy savings into any residential retrofit project.

- A specific calculation method for the UK protocol should be developed by drawing upon existing data sets and monitoring retrofit programmes as they are rolled out. Candidate models should be developed and tested to evaluate how independent variables contribute to the accuracy of the final energy savings calculation, to create a workable yet sufficiently accurate approach.

- Open source code with the calculation method(s) behind the protocol should be published, allowing multiple software and service providers to provide metered energy savings solutions based on a consistent approach.

1. Background

The CEEB and its members are supporting the implementation of selected demonstration projects to support the scaling of finance for green home retrofits, including the development of of a standardised methodology for introducing metered energy saving calculations into the UK.

1. Background

The CEEB was established by the Green Finance Institute in December 2019, with support from the climate change think tank E3G, to develop the market for financing a net-zero carbon and climate-resilient built environment. Formed of over 300 individual members from the finance, property and energy sectors, and across policy, academia and non-profit organisations, the Coalition identified metered energy savings as a critical enabler of capital flows in its report, *Financing energy efficient buildings: the path to retrofit at scale.*[1] The CEEB and its members are supporting the implementation of selected demonstration projects, including the development of a standardised methodology for introducing metered energy saving calculations into the UK.

Since March 2020, the CEEB has assembled a Metered Energy Savings Working Group of stakeholders from the finance, energy, retrofit and academic sectors; drawing on the expertise of over 20 organisations (see Annex II for a full list). Guided by EnergyPro's chairpersonship, the group has gained cross-sectoral inputs on the development of an industry-recognised protocol to measure UK metered energy savings. The Working Group hosted a series of expert workshops to better understand the data inputs required and how these might be accessed; how to capture carbon savings; and to explore ongoing pilot projects where the methodology could be tested.

This paper is the primary output from the Working Group and has been peer reviewed by members of the Coalition. It also draws on input from University College London. The paper sets out a proposal for a UK metered energy savings protocol. In parallel, the Working Group has begun identifying pilot retrofit projects to test the proposed approach using real-world data and to advance the development of the proposed protocol towards eventual open source publication.

[1] Green Finance Institute (2020) Financing energy efficient buildings: the path to retrofit at scale

2. Introduction to metered energy savings

Metered energy savings calculations can be as close to capturing real time performance as the underlying data allows.

2. Introduction to metered energy savings

An energy saving is the absence of energy use compared to a baseline – how much a building would have used if an energy efficiency retrofit had not been implemented. We cannot directly measure this hypothetical scenario, or 'counterfactual baseline', so the current industry approach avoids this problem by simply estimating the overall saving from a particular measure, such as new insulation or glazing. This estimation approach is known as 'deeming'.

This approach has some merits. It is relatively simple to administer and offers some certainty for contractors, implementers of energy efficiency programmes and institutions providing finance. However, there are many downsides. The estimated, or deemed, savings may bear no resemblance to the savings that households actually see on their energy bills after a retrofit. Nor do deemed savings distinguish between a bad installation and a good one, so quality work from energy efficiency contractors is not incentivised. For finance institutions, the estimation is too imprecise to calculate the risks and returns underpinning the economics of financial products and services.

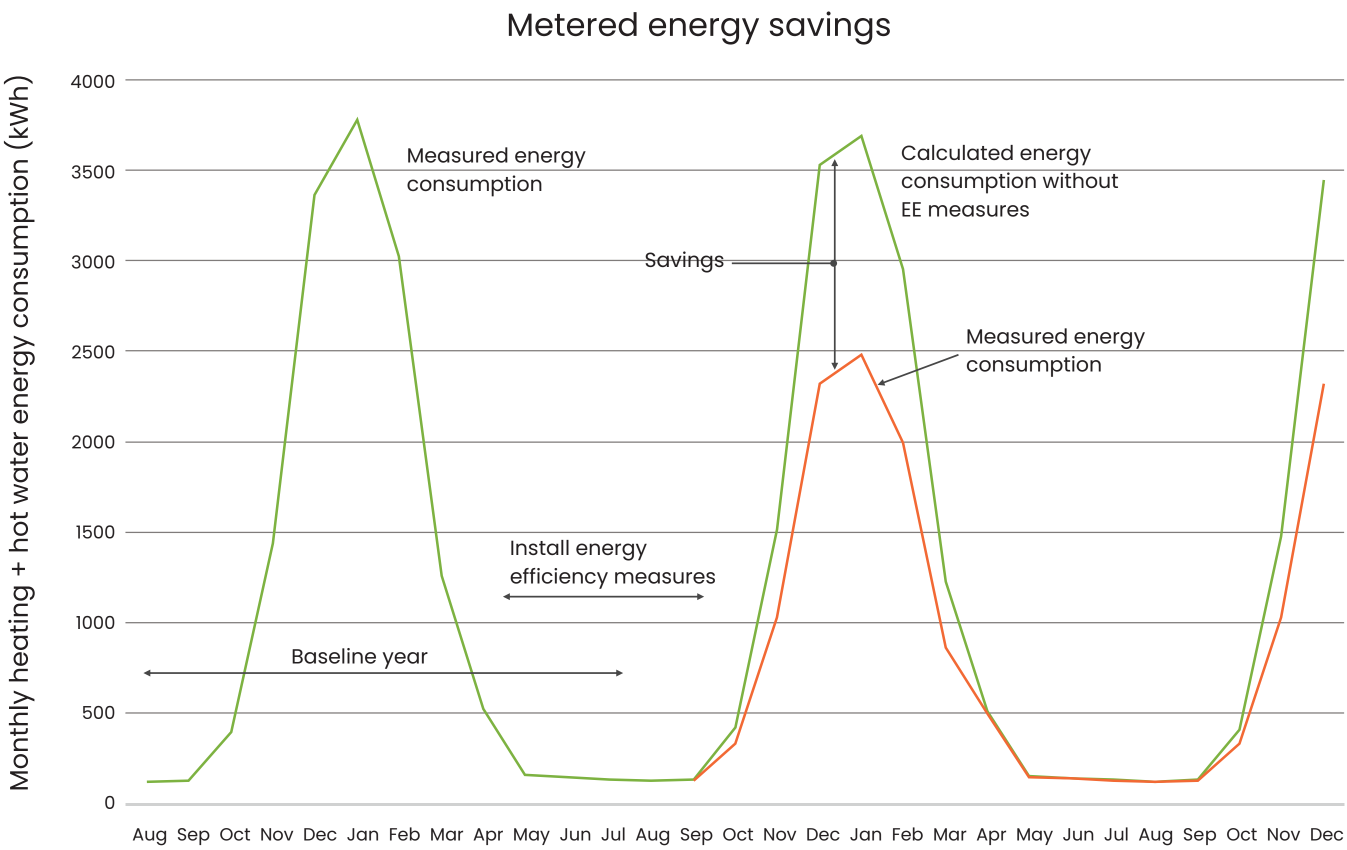


Figure 1: Metered energy savings in practice - establishing a baseline and measuring energy consumption

Deemed estimates also sell the potential of energy efficiency short at a time when efforts to decarbonise the UK are transforming its energy system. With the integration of renewable energy and the adoption of electric vehicles, network operators face new challenges about how to meet this increased demand. In many cases, investing modest amounts in energy efficiency to reduce household consumption would be a better solution than building expensive new infrastructure to create more capacity. Deemed savings are not sufficient for these sorts of assessments, as system planners need to know exactly when, where and how much energy will be saved.

Technology is now sufficiently sophisticated to turn efficiency into a time and location specific smart resource by 'metering' energy savings. While energy efficiency cannot actually be metered because it is not directly quantifiable, it is possible to meter energy use on a very accurate, frequent basis using a smart meter. It is then possible to calculate energy savings by comparing this meter reading data to the estimated counterfactual baseline, which is the estimated amount of energy that would have been used without an energy efficiency retrofit taking place (Figure 1). This approach, known as measurement and verification (M&V), has been used in large non-residential energy efficiency projects for several years. M&V calculations are typically carried out by an engineer and based on global industry standards, but the calculations still have subjective components, which means that the eventual savings can be over or underestimated.

Metered energy savings take the principles of M&V and embed them in an automated software platform. The software takes meter readings and other inputs such as local temperature conditions and uses a fixed, transparent, open source methodology to calculate near-real-time savings and avoided megawatt hours of energy use. The calculations can be as close to real time as the underlying data allow. If the meter readings provided are based on half-hourly smart meter readings, for example, the savings calculations are also updated every 30 minutes.

Taken across a portfolio of home retrofit projects, this approach reliably quantifies the true, weather-normalised savings achieved by energy efficiency programmes. In any portfolio, some projects will exceed expected performance, while others will underperform, but these effects balance out in a properly targeted programme (Figure 2).[2]

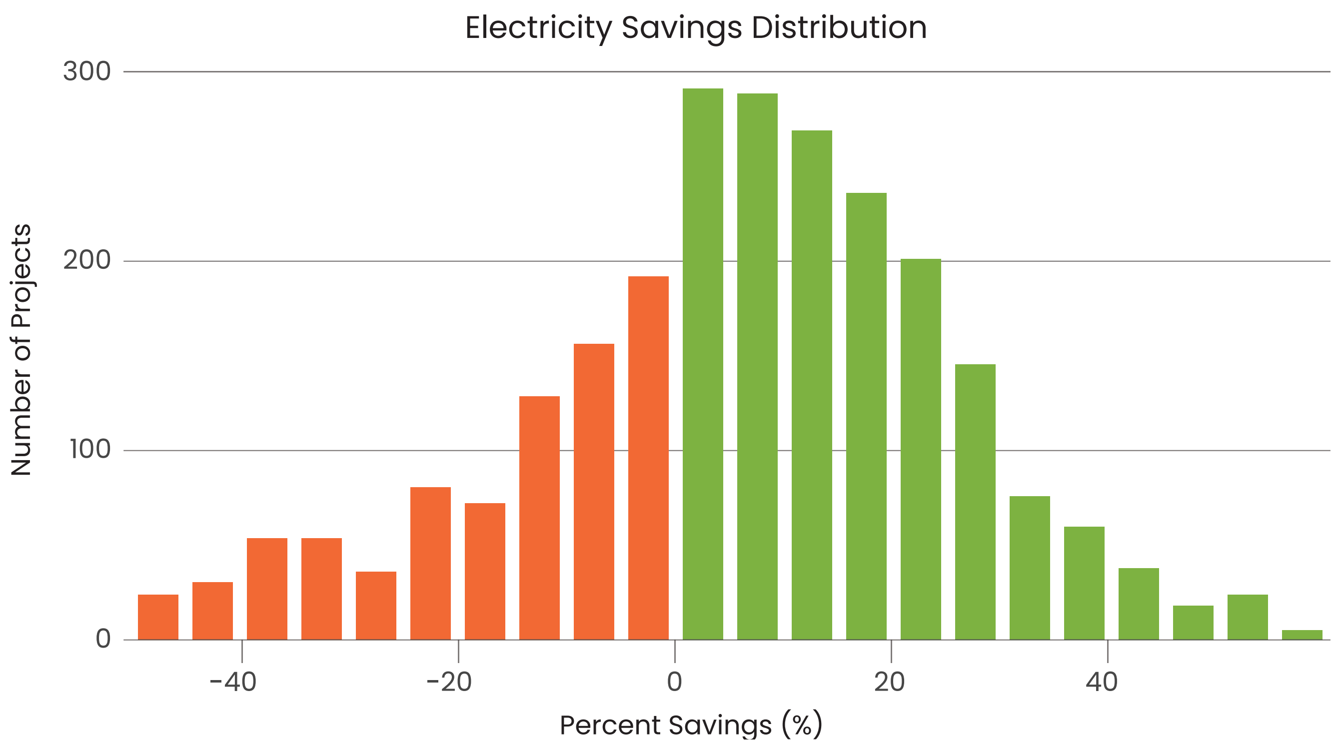


Figure 2: Distribution of realised electricity savings across a large sample of retrofit projects

[2] https://www.sciencedirect.com/science/article/abs/pii/S1040619019302027?dgcid=author

Metered energy savings are already transforming energy efficiency in California and elsewhere in the US and have provided new ways of structuring incentives and markets (see Case Study 1 on CalTRACK). The approach incorporates both the need for energy efficiency (permanent demand reductions) and flexibility (temporary shifts in consumption or generation) that take place behind the household's utility meter.

Case Study 1: Metered energy savings and pay-for-performance in California

The industry-wide adoption of the CalTRACK standard methodology for calculating baseline energy consumption has been crucial to the growth of the retrofit market in California and other states.

CalTRACK is a set of empirically tested methods to standardise the way normalised, meter-based changes in energy consumption are measured and reported.[3] Specifically designed for buildings and environmental conditions in the US, CalTRACK is implemented through open source software and these methods can be used to support energy efficiency. CalTRACK calculates avoided energy use by defining the counterfactual baseline – the estimated consumption of energy in a building following a retrofit – as if the retrofit had not taken place. As well as energy efficiency, CalTRACK can be used to monitor the effect of any Behind-the-Meter (BTM) Distributed Energy Resource (DER), such as solar panels or fuel cells installed in the building.

The CalTRACK methodology was developed to address challenges facing California's energy system and has been highly effective to date. The approach[4] enables the electrical energy use avoided as a result of retrofits to be measured, valued and remunerated. It allows utilities facing energy efficiency obligations to shape their load curves, assisted by the amount of electric heating, ventilation and air-conditioning systems that have be improved by retrofit engineers and the widespread deployment of Advanced Metering (smart metering), which provides valuable data for utilities and their contractors.

[3] CalTRACK (2020), CalTRACK Method.

[4] For example see Lawrence Berkeley National Laboratory (2017) The Status and Promise of Advanced M&V: An Overview of "M&V 2.0" Methods, Tools, and Applications.

Case Study 2: International initiatives on metered energy savings and Pay-for-Performance

The SENSEI project, funded by the EU Horizon 2020 programme, is developing models that enable energy efficiency to be rewarded as an energy resource and a new grid service. As part of the project, 11 Pay-for-Performance (P4P) pilots for energy efficiency in buildings were examined (see Table 1).

Name	Location	Duration (incl. pilot)
Commercial programmes (larger buildings)		
New Jersey – Pay-for-Performance Commercial & Industrial (C&I) programme	NJ, US	2009-present (12 years)
Energy Trust of Oregon – Pay-for-Performance Pilot	OR, US	2014-present (7 years)
District of Columbia Sustainable Energy Utility (DCSEU) – Pay-for-Performance programme	DC, US	2019-present (2 year)
Seattle City Light – Deep Retrofit Pay-for-Performance (P4P) programme	WA, US	2013-present (8 years)
Puget Sound Energy – Pay-for-Performance pilot	WA, US	2018-present (3 years)
Efficiency Vermont – Continuous Energy Improvement	VT, US	2014-present (7 years)
Ontario Save on Energy – Energy Performance Program	ON, CA	2013-present (6 years)
Commercial programmes (smaller buildings)		
New York State Energy Research and Development Authority (NYSERDA) – Business Energy Pro	NY, US	2019-present (2 year)
Bay Area Regional Energy Network (BayREN) – Small and Medium Commercial Buildings Pay-for-Performance programme	CA, US	2018-present (3 year)
Residential programmes		
Pacific Gas and Electric Company (PG&E) – Residential Pay-for-Performance programmes	CA, US	2018-present (3 years)
Open programmes		
Germany – Energy Savings Meter	DE, EU	2016-present (4 years)

Table 1: List of Pay-for-Performance case studies reviewed by the SENSEI project

Source: SENSEI. (2020). Experience and lessons learned from P4P pilots for energy efficiency. Deliverable D4.4 of the SENSEI project, funded by the H2020 programme, grant agreement number: 847066.

The P4P programmes capture different operational, behavioural and technical measures and this influences the measurement and verification protocols used. Seven of the programmes use the methodology and guidelines of the International Performance Measurement and Verification Protocol (IPMVP) Option C. This determines savings by measuring energy consumption and demand at the whole building level.[6] IPMVP Option C guidelines suggest that savings should typically exceed 10% of baseline consumption in order to accurately discriminate the savings from baseline data. Seattle City Light is one such programme that uses IPMVP Option C and requires minimum savings of 15%.

The New Jersey Existing Buildings Programme and the Energy Trust of Oregon use the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Guideline 14, Measurement of Energy and Demand Savings, which is similar to, but more restrictive than IPMVP. The three P4P programmes targeting smaller buildings in California and New York use the CalTRACK method. The German Energy Savings Meter uses its own bespoke methodology to determine energy savings. In the residential sector, three years of data from annual energy bills and weather records are used to construct the counterfactual baseline.

All of the programmes reviewed are small scale pilots and evidence collected over the next two years will inform which programmes will be rolled out more broadly. The SENSEI project is also encouraging more pilot programmes in Europe.

[6] International Performance Measurement & Verification Protocol (2002) Concepts and Options for Determining Energy and Water Savings.

3. UK context

A home-grown approach to metered energy savings is critical for this valuable tool to gain traction in the UK.

3. UK context

A home-grown approach to metered energy savings is critical for this valuable tool to gain traction in the UK. While seeing the concept demonstrated in other markets is helpful, and software and programme designs have matured as a result, a metered energy savings protocol in the UK must explicitly meet the demands of the UK market and engage with industry if it is to build awareness and acceptance.

3.1 Stakeholders

In the UK, there are a range of stakeholders who could benefit from a standardised approach to capturing metered energy savings. These are outlined in Table 2.

Stakeholder group	Potential benefits
Homeowners and tenants	Homeowners could have a more accurate insight into the benefit of green home retrofits than is currently provided by EPCs, and could better understand the benefits offered by Energy Service Companies that often guarantee a level of savings. Tenants could accurately monitor the money they are saving as a result of energy efficiency measures installed by landlords.
Financial institutions	Financial institutions could better assess the risk of providing capital to certain projects, which could help underpin the development of new financial products and services. For example, energy efficiency could be funded through project finance in the same way that power plants and distributed energy resources are financed today. It could also help lenders certify the environmental impact of green home retrofits – a common challenge to scaling the green home finance market - and help measure the overall energy performance of mortgage portfolios. Insurers could underwrite energy efficiency programmes based on quality risk data, providing protection for both consumers and investors, and enable contractors to offer performance guarantees.
Retrofit roles specified by PAS 2035	The PAS 2035: Specification for the Energy Retrofit of Domestic Buildings – specifies that retrofit roles include an advisor, assessor, coordinator, designer and evaluator. Each of these professionals could utilise metered energy savings to inform their work. Advisors could use aggregated information on metered energy savings to understand which energy efficiency improvements allow the greatest energy cost savings and carbon reduction. Evaluators could use metered energy savings data to measure the performance of new retrofits, ensuring that guarantees are met and the promised energy and carbon savings are delivered. Linking the metered energy savings protocol with the British Standard for Building Performance Evaluation (BPE) that is currently under development will help to ensure the protocol can be used to fulfil the roles required by PAS 2035.
Retrofit, energy and heat service providers	Providers of programmes such as Heat as a Service could calculate the real-time cost savings of retrofit measures, and therefore more accurately price their services. With insight into actual performance, contractors could offer real savings guarantees and give their clients a means of recourse if there was a shortfall in savings. Providers with work currently underway in the UK include Energiesprong, RetrofitWorks and Sero Homes.
Utilities and energy companies	Business models that contract for energy efficiency on a Pay-for-Performance basis could be created and scaled. A utility could establish an energy efficiency P4P programme, with monitoring and verification of cash flows from portfolio-wide energy efficiency metering.

Stakeholder group	Potential benefits
Grid network providers and distribution system operators	There are 14 licensed distribution network operators in the UK and each is responsible for a regional distribution services area. These are represented by the Energy Networks Association. System planners could have an enhanced understanding of exactly when, where and how much energy can be saved. A standardised approach could unlock social benefits (e.g. lower energy bills) and provide more sources of energy flexibility to meet shifting demand.
Aggregators and distributed energy resources	Metering energy savings on a sub-daily basis could allow providers of flexibility and demand response services to offer load shaping services, effectively combining efficiency (demand reduction) and flexibility (demand shifting) services. Changes to how such services are procured would be necessary, particularly to the baseline used to evaluate the impact of services[7], but the availability of a viable metered energy savings tool would help accelerate this shift.
Government departments and public sector programmes	Demand-side efficiency could contribute to the decarbonisation of the energy system, helping national and local governments measure and monitor the carbon savings associated with public retrofit programmes, including progress towards targets, and help support funding bids. Some government departments and local authorities are already moving forward with performance-based evaluation methods. The metered energy savings approach could also help enhance EPC calculations.

Table 2: Stakeholders that could benefit from metered energy savings in the UK

3.1: New products, business models and markets

Achieving net zero carbon emissions in the UK by 2050 will require the decarbonisation of around 27 million homes through a combination of energy efficiency and low carbon heat measures. Building the market for home decarbonisation will require new commercial models and offers that consumers can trust. For this to work, consumers must have confidence that adaptations and low carbon technologies in their home will deliver the cost and energy savings promised, as well as improved climate and health outcomes. Ongoing research by the Energy Systems Catapult has found that low confidence over potential energy savings prevents many consumers from taking steps to decarbonise their homes or seek third-party finance to fund such projects.[8] The introduction of MCS and PAS 2035 standards are a breakthrough, but a gap persists between predicted savings and the actual reduction of energy bills.

Metered energy savings enable any performance gaps to be investigated and addressed after a retrofit project is delivered. For example, the incorrect specification of equipment or materials, installation problems, or a miscalculation of the savings potential could lead to underperformance. Without systematic empirical measurement, these shortfalls are not routinely captured and rarely addressed unless the problem represents a major breach of an installer or another party's obligations. Metered energy savings embed evaluation in every project – as envisaged by the PAS 2035 retrofit standard – allowing the retrofit industry to improve performance, quality and customer confidence.

[7] This is being considered via the Elexon working group on P376 'Utilising a Baselining Methodology to set Physical Notifications'. https://www.elexon.co.uk/mod-proposal/p376/

[8] https://es.catapult.org.uk/capabilities/consumer-insight/market-research/

A number of potential applications of metered energy savings have been identified and summarised in Table 3, which will inform the development of the proposed protocol.

Applications of metered energy savings	Benefits from using metered energy savings	Data requirements
Heat or Comfort as a Service: Measure energy savings to provide homeowners and investors with confidence, and reduce the risk to service providers	• Standardised calculation methodology • Verifiable baseline assessment methodology • Ability to predict savings	• Standardised calculation methodology • Verifiable baseline assessment methodology • Ability to predict savings • Smart meter data - if not available, energy billing data • Occupant survey may be valuable to assess customer satisfaction • Internal temperature and relative humidity • Weather data
Performance guarantees for retrofit financing: Measure performance for Pay-as-you-Save, guaranteed savings, insurance and other models	• Replicable and reliable method of calculating the energy performance after a retrofit project • Method to predict performance before work on the basis of in-use data	• Smart meter data • Internal temperature data • Weather data • Solar data
Area-based retrofits: Assess the benefits of different retrofit packages and identify candidate properties. This evidence could support financial offers such as Demand Aggregation Financing	• Robust estimation of the potential benefit to similar properties from standard but customisable retrofit solutions	• Smart meter data • Contextual data on building types
Help lenders verify and measure 'greenness': Lenders can verify the energy efficiency savings that financial products and services have enabled, and can better assess the energy performance of mortgage portfolios than with EPC data alone	• Standardised calculation methodology • Verifiable baseline assessment methodology • Ability to accurately predict savings	• Smart meter data - if not available, energy billing data - for time before and after the funded project • Information on the retrofit project
Energy efficiency projects participating in flexibility and capacity markets	• A standardised method for calculating baseline energy use with accuracy and certainty, similar to CalTRACK • Assign monetary value to a saving (avoided energy use)	• Smart meter energy data • Weather data • Information on the project or retrofit measure, including the installation date

Applications of metered energy savings	Benefits from using metered energy savings	Data requirements
Energy efficiency obligation schemes (e.g. ECO, CERT successor): Replace 'deemed' methodologies with performance measurement	• Standardised calculation methodology to ensure fair treatment of suppliers with respect to targets	• Smart meter data • Internal temperature data • Weather data
ESCo model or Pay-as-you-Save for domestic buildings: Measure actual efficiency gains and improve certainty on energy expenditure, which may enable lower interest rates on funding options	• Standard methodology for data collection with high ability to replicate real life setting	• Energy consumption • Internal temperature data • Weather data • Other measures of internal quality such as light, CO2 level and humidity
'Avoided carbon' outcomes of efficiency and flexibility after a retrofit project	• A standard way to signal to in-home devices that the carbon emissions of grid-supplied electricity are particularly high, for example to cause batteries to discharge so they reduce the carbon emissions of the home • Standard process to evaluate carbon mitigation from an efficiency or flexibility intervention on a regular basis (e.g. half-hourly)	• Grid carbon intensity data – available on a half-hourly basis – to provide an assessment of the carbon impact, rather than annual carbon intensity averages • More precise data about the true carbon emissions of energy supplied to a home may be needed in some circumstances. For example, if a diesel generator was being used on the local distribution system it would increase emissions locally, so using the average figure for grid carbon intensity would be an under-estimate. This data could be used to signal to in-home devices that they should shut down or switch to batteries in order to reduce emissions
Assessment of policy effectiveness based on delivered performance to inform regulation	• A standardised approach to help inform policy and relevant regulations	• Smart meter data • Internal temperature data • Contextual information on buildings
Building renovation passports: Enhance the data richness of this tool, which includes a property logbook with information on previous renovations and energy performance, and a roadmap of retrofits to decarbonise the property	• Metered energy savings can inform the data inputs and outputs of a Building Renovation Passport, helping households see the benefits of retrofit measures undertaken	• Information on retrofit project • Information on energy consumption

Table 3: Potential applications of metered energy savings in the UK

Case Study 3: Smart meter roll out

Smart meters have potential to underpin metered energy savings in the UK. Currently, around 40% of homes have a smart meter,[9] a number likely to increase in coming years, making it more likely that dwellings receiving retrofits will already have smart meter data available. However, some residential categories, particularly social housing and the private rented sector, have a lower proportion of smart meters than the general population, so other data sources will be needed. There are also homes that use fuels other than gas and electricity – some 2.3 million homes are off the gas grid and may use unmetered energy for heating, such as oil or biomass. Homes can also generate energy from unmetered sources such as solar panels or use domestic metered energy outside the home – to charge electric vehicles, for example. Nonetheless, a metered energy savings methodology should incorporate the potential synergies and data that is generated through smart meter roll out.

One advantage is that smart meters store up to 13 months of historic data, which can be used as a baseline to calculate future energy savings resulting from efficiency measures, when it is often not practical to delay the installation of green retrofits to collect historical monitoring data. Although it may be possible to calculate the effect of some types of interventions in a few days, this is not the case for all energy efficiency improvements, and in general one year's worth of historical data is required.

The UK government and utilities have made a significant investment to establish a secure and resilient monitoring system for smart meters through the Data and Communications Company (DCC). Metered energy data has strict requirements under the Smart Energy Code (SEC) and the DCC operates an SEC-compliant system. A metered energy savings protocol will require a thorough legal review to guarantee it is compliant with the SEC and Data Access and Privacy Framework, and ensure that energy data can be collected from households while protecting personal data.

[9] BEIS (2019) LSOA estimates of properties not connected to the gas network: BEIS (2020) Smart Meter Statistics in Great Britain.

4. Proposed protocol

The CEEB workshops considered the key data inputs for a UK metered energy savings protocol, as well as issues concerning data availability and practicality.

4.1 Key recommendations

The CEEB workshops considered the key data inputs for a UK metered energy savings protocol, as well as issues concerning data availability and practicality. The key recommendations are presented in the following sections.

Essential: enables core functionality

- **Retrofit dates:** Dates on which the retrofit project commenced and was completed. The former marks the end of the baseline period, while the latter marks the start of the savings monitoring period.

- **Identifier:** A unique identification code for the project. Details of the address or Meter Point Administration Number (MPAN) and specific details on the project are captured separately to allow processing by the metered energy savings protocol to take place on an anonymised basis.

- **Energy consumption:** Data concerning how much energy a household consumed before and after a retrofit or renovation measure was installed. This could be captured through smart meter data or other means (see Table 4 on data sources). Data should be captured for all energy supplies to the home, which in most cases will be electricity and gas.

- **Weather:** The energy demand of heating homes (the major use of energy in domestic buildings) is highly dependent on the weather, and with the introduction of more complex technologies such as heat pumps, this performance is even more sensitive. Specifically, the protocol will require data on outdoor air temperature in the form of half-hourly temperature readings, or alternatively, heating and cooling degree days, a common method for expressing how hard heating and cooling equipment must work to compensate for outdoor air temperature.

- **Occupancy:** How much metered energy a building uses is ultimately controlled by the occupants, which is impacted by the number and age of the occupants, as well as household income. Collecting this data is impractical and undesirable from a data protection perspective. Fortunately, measurement and verification methods, including CalTRACK, have demonstrated how proxies for occupancy can be used instead of actual household occupancy data. Incorporating time and date information into the metered energy savings calculations, for example, accounts for occupancy changes. Energy use patterns on a Sunday will differ from a Monday in many households and energy use on a Bank Holiday will differ from a typical weekday.

Highly desirable: improves usefulness of the protocol

- **Indoor environmental quality (IEQ) monitoring:** Monitoring the indoor temperature of a dwelling is important to ensure that homes are comfortably heated. Most UK homes are not well insulated or uniformly heated. The Mean Internal Temperature (MIT) is the critical metric from an energy standpoint and monitoring this ideally requires temperature sensors in all rooms, although a useful estimate may be gained from a smaller number of monitoring points. In addition, relative humidity and CO2 concentration are considered key metrics to monitor. Changes in indoor CO2 concentration may be strongly correlated with changes in occupancy (see above). Integrating and standardising IEQ in the protocol means that the broad benefits of energy efficiency projects can be valued.

- **Carbon savings:** The protocol will incorporate a calculation of avoided CO2e emissions on a half-hourly basis, or at the highest frequency permitted by the other data streams in use. This will be achieved by multiplying avoided energy consumption (in kilowatt hours) by the relevant carbon conversion factor, based on specific National Grid figures. This approach will allow emissions savings to be evaluated following retrofit projects, including flexibility projects, but these carbon savings are not intended to determine the use of Behind-the-Meter assets such as storage batteries. This would require real-time data on marginal carbon abatement potential and that technology, and its cost, is not justified for the majority of retrofit projects.

- **Equipment data:** In principle, the accuracy of baseline models can be improved by incorporating data from assets within the home, such as smart thermostats, hot water flow meters or smart devices. However, the improvement in accuracy needs to be traded against the considerable complexity of integrating proprietary data streams into the savings calculation. Subject to further investigation, electric vehicle chargers may merit integration, because of the significant impact these have on household electricity use patterns.

Context data: allows enhanced analysis and programme management

The information below is not necessary to evaluate projects on the basis of avoided energy consumption and indoor environment quality, but the more contextual data that is available, the greater the benefits of the metered savings approach.

- **Intervention:** Captures what retrofit measures were installed and how and when these were implemented. This can include things such as the make, model and location of the technology installed, who installed it and any installation challenges. It can include very specific data that can impact performance, such as the solar shading of components, the installation of antifreeze or the flushing out of radiators. Many retrofit measures may not be purely technical, in which case some record of the social intervention will be required.

- **Contractor:** The contractor(s) that carried out the retrofit project. In some US jurisdictions, this is used to calculate the Pay-for-Performance payments that contractors receive based on the energy savings experienced by the household.

- **Address:** The location of the property and/or the Meter Point Administration Number (MPAN). Capturing the latter would locate the retrofit project geographically and on the energy grid, allowing Behind-the-Meter savings (from solar panels or other energy generating devices installed at the property) and demand side management to be treated as a distributed energy resource – for instance through load shaping by reducing, increasing or shifting demand. Aggregating such resources and monetising the efficiency and flexibility benefits could be a key driver for the use of metered energy savings.

- **Building and services:** Comprehensive and reliable data can be expensive to collect, requiring a qualified surveyor and building services engineer. However, over half of buildings in the UK now have an EPC and SAP rating and efforts are underway to improve the accuracy of this data. Models such as 3DStock are already pulling together many key buildings and cross-checking data from different sources to improve the quality and reliability. Key parameters include building age, size and building type (e.g. detached), heating type and wall and loft insulation. The CEEB is also developing a standardised framework for a Building Renovation Passport, which could be a useful information resource in the future.

4.2 Data sources

Table 4 summarises the data sources a metered energy savings protocol should be able to utilise. These are ranked in order of preference. A published version of the protocol will contain guidance for retrofit professionals on how to acquire data under each scenario.

Data collection and baselining

Data collection route	Electricity data source	Electricity baseline length, granularity	Gas data source	Gas baseline length	Other fuel data source	Other fuel baseline length	Indoor Environment Quality (IEQ) data source	IEQ baseline length
1. (Preferred) - single in-home Consumer Access Device (CAD)	Smart meter via Consumer Access Device (CAD)	12 months (preferred) or apply data sufficiency test Half-hourly	Smart meter via CAD	12 months (preferred) or full heating season (minimum) Half-hourly	In-home monitoring via CAD	12 months (preferred) or full heating season (minimum) Half-hourly	In-home sensors via CAD	None
2. Smart but no CAD	Smart meter via Smart DCC or Energy Company	12 months (preferred) or apply data sufficiency test Half-hourly	Smart meter via Smart DCC or Energy Company	12 months (preferred) or full heating season (minimum) Half-hourly	In-home monitoring via other comms	12 months (preferred) or full heating season (minimum) Half-hourly	In-home sensors via other comms	None
3. Other meters or Automatic Meter Reading (AMR)	Proprietary clamp meter and comms	12 months (preferred) or apply data sufficiency test Half-hourly	Proprietary gas meter and comms	12 months (preferred) or apply data sufficiency test Half-hourly	Proprietary meter / sensor and comms	12 months (preferred) or apply data sufficiency test Half-hourly	In-home sensors via other comms	None
4. Manual readings	Regular manual readings, submitted via app or text message	12 months	Regular manual readings, submitted via app or text message	12 months	Regular manual readings, submitted via app or text message	12 months	None	None

Table 4: Data sources to be incorporated into a metered energy savings protocol

4.3 Calculations and outputs

The operating model and process for generating a counterfactual baseline model against which savings can be measured are shown in Figures 3 and 4. This includes the near-real-time calculation process used to carry out this measurement.

The counterfactual baseline model proposed draws on the CalTRACK concept of Normalised Metered Energy Consumption (NMEC). This uses regression modelling against a standard set of independent variables to account for most of the variation in a building's energy use. As discussed above, input data are selected based on cost and practicality. The goal is not to produce a perfectly accurate model, rather the model needs to be sufficiently accurate that the energy savings identified are statistically significant. For this reason, the software calculation should also return the model statistics, particularly the coefficient of variation, to indicate how reliable the savings measurement is for any given building. Based on the US experience, a portfolio view of a large number of projects can provide a reliable assessment of energy savings performance, even in cases where the model accuracy on individual projects is relatively low.

Counterfactual model

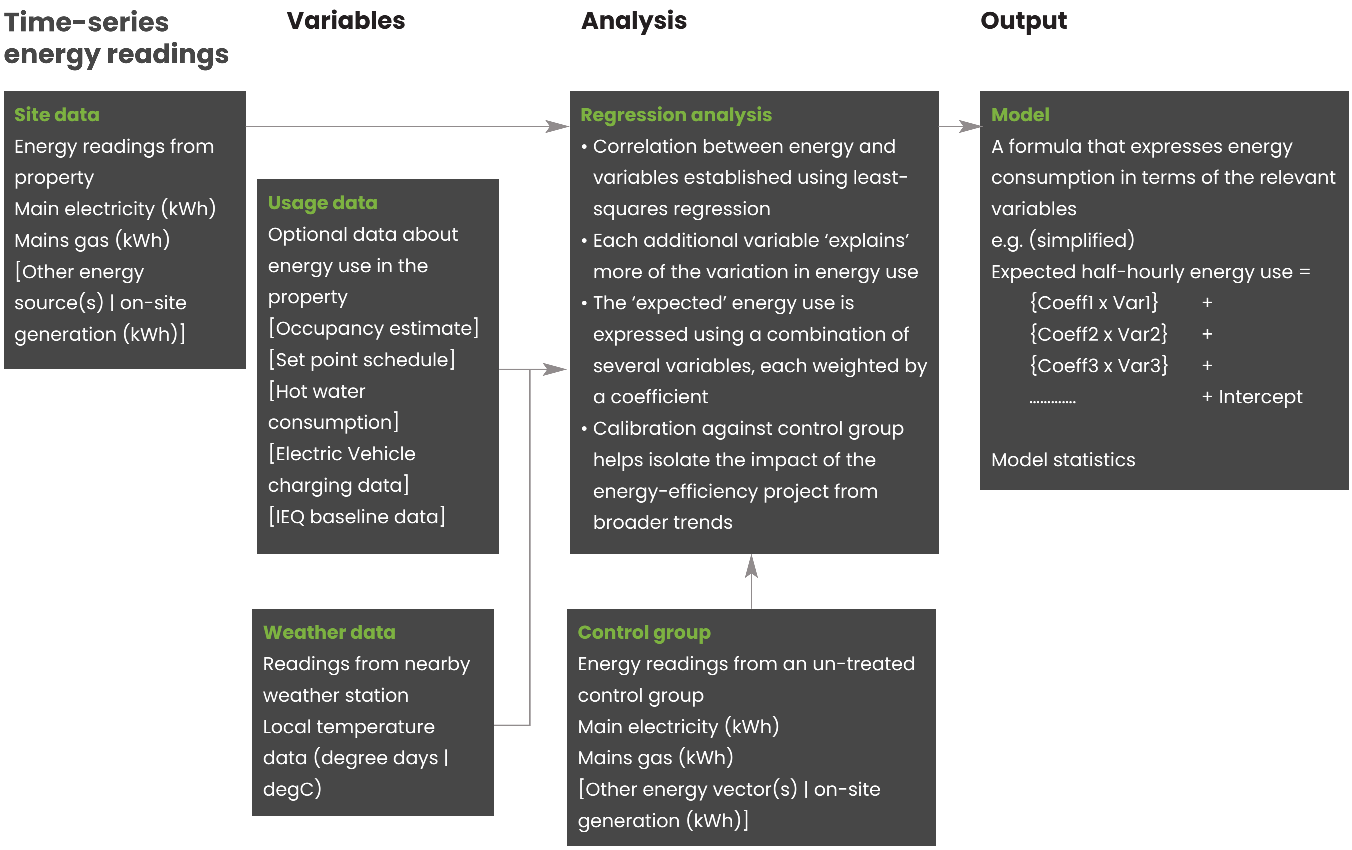


Figure 3: Model for establishing a counterfactual baseline

Software should use the counterfactual baseline to calculate the energy savings (avoided energy use) and other outputs on a periodic basis. The recommended default time period should be once every 30 minutes to align with the frequency of UK electricity settlement, however this could pose data management and storage challenges, particularly if 'live' readings are required. For some applications of metered energy savings, it is likely that daily calculations would be sufficient. In general, the frequency of the calculation is limited by the least frequent input variable. For example, if only monthly gas readings were available, energy savings calculations would be limited to a monthly basis.

As discussed above, indoor environmental quality (IEQ) measurements should be collected once retrofit measures are installed. This means that IEQ readings will not contribute to the counterfactual baseline model, which instead will use an occupancy proxy similar to that used by CalTRACK. Once IEQ readings are available, they can offer a more accurate proxy for relative occupancy - this can be used in savings calculations, as shown in Figure 4. IEQ readings will be compared against benchmark figures for acceptable indoor environments to verify that the retrofit is delivering a good outcome for the household. These benchmark figures may be based on industry standards, or established for individual homes based on the outputs of the initial survey.

The calculation software should return model statistics, along with the defined outputs, automatically identifying sites where an M&V specialist needs to investigate further. It is proposed that site level and portfolio level analytics are carried out in a separate software layer, which will involve matching home-level output data against address-level data held in a separate database. This ensures that calculations in the metered energy savings software remain anonymous.

Half-hourly calculation

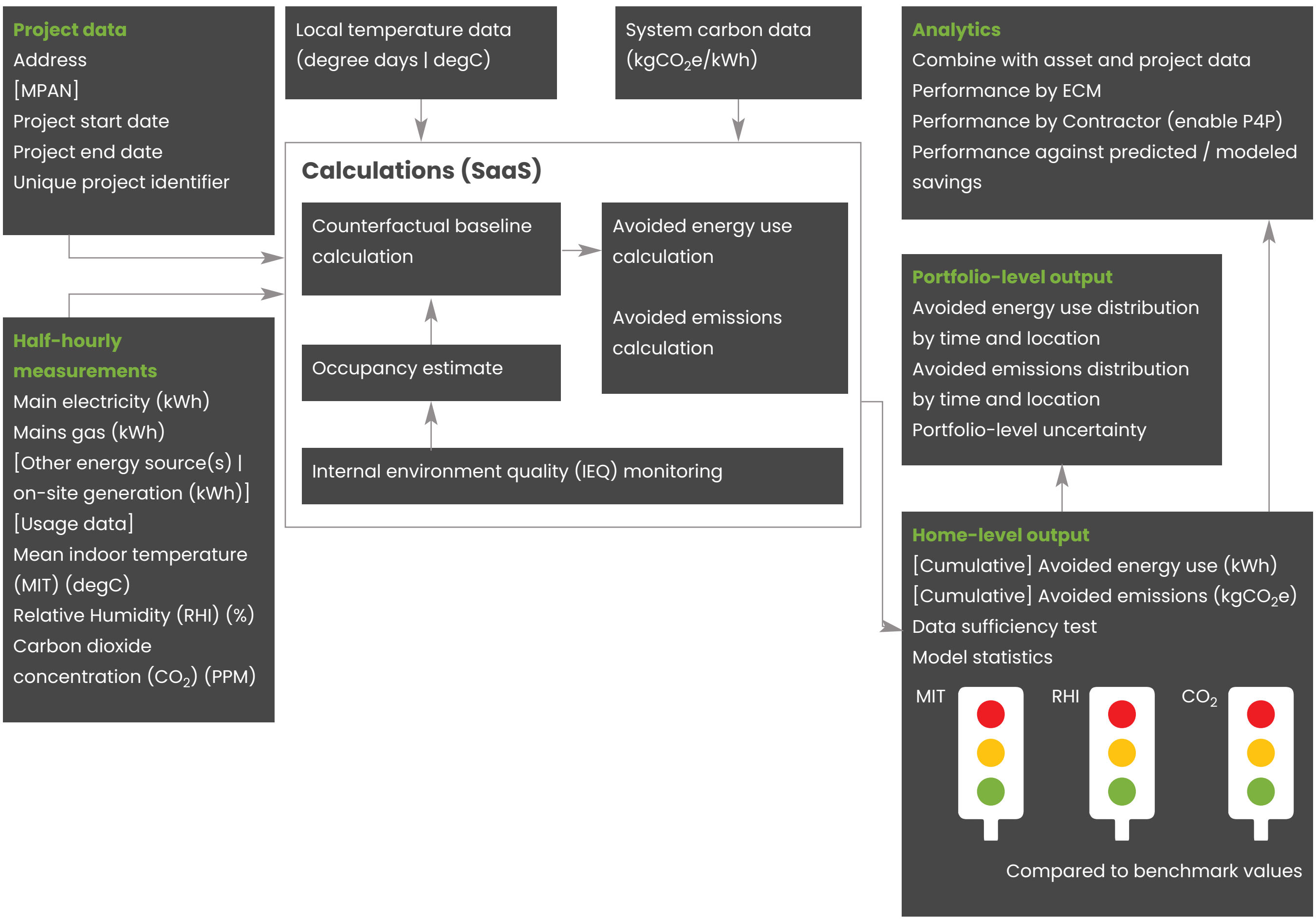


Figure 4: Model for calculating metered energy savings

In principle, the proposed metered energy savings approach is applicable to any type of building, given a site-specific model is generated for each project. The primary limitation is data collection, which will likely require the installation of a Consumer Access Device (CAD) to collect smart meter data (or data from a similar device) and to monitor IEQ parameters. Further work is needed to evaluate commercially viable hardware options, although initial analysis indicated that such solutions are available and affordable.

4.4 Options to trial metered energy savings in the UK

To implement the proposed protocol, a systematic evaluation of the inputs is necessary. Different approaches can be used to identify the most important inputs:

- Randomised Control Trials are often considered the 'gold standard'. This requires the careful selection of an adequately sized population, randomly assigning participants to have or not have a retrofit, and measuring the impact over time and across cohorts.
- An alternative is to control for all the variables that may impact performance other than the retrofit. This is normally undertaken in controlled conditions, such as a laboratory.

Both approaches are problematic for building energy use, as buildings are not mass produced to tight tolerances and identical buildings quickly get modified by their occupants. Therefore, the sector normally uses a mixed method. Laboratory tests give an initial indicator of the potential, normally using standard test conditions. These results are often followed by a field trial for more insight into real-world conditions, with either missing longitudinal or control data and self-selected populations.

The CEEB Working Group recommends a mixed method approach, which draws upon existing literature and studies on the impact of key driving variables on residential energy use and incorporates further primary lab-based testing if required. Academic partners with experience in these trials will be directly involved in the development of the protocol.

Once the inputs have been evaluated, the model for calculating the counterfactual baseline must be assessed. The initial model will use the CalTRACK methods as a template, which will be systematically refined by subjecting the model to testing with real data from live and historic energy efficiency retrofit projects. The development process will evaluate how the series of independent variables, will contribute to the model's ability to correctly quantify savings, in order to arrive at a modelling method that is both practical and sufficiently accurate.

5. Next steps

The Working Group will continue to develop the protocol and support a number of projects aimed at advancing metered energy savings through technical consultancy and advice, ongoing industry engagement, academic input, development and coding.

5. Next steps

The CEEB invites retrofit, energy, data and finance professionals to respond with their comments and feedback on the recommendations in this report for a metered energy savings protocol, contacting **CEEB@gfi.green** with any feedback.

The Working Group will continue to develop the protocol based on this feedback and support a number of projects aimed at advancing metered energy savings through technical consultancy and advice, ongoing industry engagement, academic input, development and coding. The projects will be informed and calibrated with real data from historic and live retrofit programmes. The key workstreams to develop metered energy savings for the UK are shown in Figure 5.

Figure 5: Key workstreams to pilot, test and develop metered energy savings for the UK

Appendices

Appendix 1: Understanding the UK retrofit market and metered energy savings applications

The Working Group explored the specific market conditions and barriers in the UK that the metered energy savings protocol must address. The table below outlines the characteristics of the UK's retrofit landscape and the implications on the design of a UK metered energy savings protocol and its potential applications.

Characteristics of the UK retrofit landscape	
Energy efficiency programmes	Currently the UK does not have any large-scale programmes similar to the obligation schemes common in US states, which is the context for the CalTRACK method being developed. This has not changed with the recent introduction of the Green Homes Grant scheme, which offers vouchers to be redeemed against a prescribed list of retrofit measures, but with no built-in evaluation. However, quality assurance has been improved over previous schemes with the requirement to use TrustMark accredited contractors. The UK does have the Energy Company Obligation (ECO), which uses modelled (deemed) energy savings based on a version of Standard Assessment Procedure (SAP), the same calculation methodology used for Energy Performance Certificates. A move to metered energy data management and storage savings would improve the ECO's quality assurance and customer protection and BEIS has been exploring how ECO could operate on a Pay-for-Performance (P4P) basis in future. The best opportunity for metered energy savings is presented by the rapid uptake of the PAS 2035 standard and the wider system of quality management being introduced into the retrofit sector resulting from the Each Home Counts review. PAS 2035 professionals need a practical, cost-effective and standardised evaluation procedure and this could be offered by a UK metered energy savings protocol. The Working Group adopted this as its defacto user profile: the aim being to create an evaluation method that all appropriately qualified retrofit professionals can use, which is ubiquitous, rather than linked to any particular programme.
Energy vectors	The Working Group discussed which energy types the proposed metered energy savings protocol should apply to, concluding that: - Electricity should be in scope, because it accounts for a substantial proportion of households' controllable demand, which is likely to grow as heat and transport are electrified. Metered energy savings offer the ability to 'measure' savings against a counterfactual baseline, which could be created in a way that accounts for vector shifting. Metered energy savings also offer the ability to measure flexibility and load shaping benefits that are unique to the electricity system. - Gas should be in scope, because heating and hot water account for a large proportion of household energy use and the UK has a high proportion of homes connected to the gas network. - The metered energy savings protocol should also be able to accommodate other fuel types such as fuel oil, although data collection will be challenging given the absence of a meter and varying calorific values. - Readings for energy produced by onsite generation, particularly rooftop solar panels, should be explicitly taken into account by the metered energy savings protocol.

Characteristics of the UK retrofit landscape	
Electrification and decarbonisation of heat	The decarbonisation of heat is likely to involve widespread electrification of heating and hot water and ultimately disconnection of many homes from mains gas. This, combined with parallel electrification of transport, presents a major challenge for electricity distribution infrastructure. Efficiency measures can help to address this and are also essential to ensure the effectiveness of electric heating for every individual home. Metered energy savings enable the reduction in energy demand achieved by efficiency measures such as insulation to be quantified, however the protocol should also consider the internal temperature performance of a home after a retrofit. Without this element, savings from heat-related measures could be under-reported in cases where the resident experiences better internal temperature conditions after the retrofit - known as 'comfort taking'. This aspect was felt to be very important given the focus on heat decarbonisation in the UK and the current widespread prevalence of fuel poverty.
Energy infrastructure	Energy efficiency measures have the potential to reduce and reshape energy demand and increase headroom in constrained network zones, however this opportunity is not yet widely understood. Accurately measuring reductions in energy demand is a prerequisite for capturing their value and may create an additional value stream for retrofits that act to defer or avert network upgrades in constrained zones. This is a significant part of the value proposition for metered energy savings, particularly if the new protocol allows efficiency and flexibility (demand shifting) to be measured, allowing a retrofit project to stack both value streams.
Condition of homes	Many UK homes, particularly in the private rented sector, have poor thermal performance and may be in a state of disrepair. Therefore, the metered energy savings protocol should explicitly monitor internal environment quality (IEQ) as well as avoided energy consumption, as many retrofit recipients and refurbishments will experience value from both. Internal temperature, relative humidity and CO2 concentration are the key metrics to monitor. Integrating and standardising their inclusion in retrofit evaluation means the broad benefits of energy efficiency projects can be valued by the new metered energy savings approach. It also means the protocol is robust to the anticipated increase in air conditioning use to combat over-heating in homes.

Characteristics of the UK retrofit landscape	
Meters, smart metering and access to data	The inclusion of time-series energy consumption data in the protocol is essential and, in principle, smart meters offer both historic data for baselining and near-live, highly granular data at a household level. However, while a number of routes to access smart meter data exist, some are costly or only practical at scale and all require customer permission. Retrofit professionals planning to use the metered energy savings protocol will require a clear process for accessing smart meter data that can be easily deployed every time a project takes place. Ideally this should be combined with the collection of IEQ data (see above). The simplest way to achieve this will be the use of an in-home Consumer Access Device (CAD) that can both communicate with smart meters and collect basic IEQ data. The requirement for a physical device has practicality and cost implications, which need to be explored in a subsequent phase of work. The approach also needs to accommodate homes that do not have a smart meter, for example by using temporary monitoring via clamp (electricity) and flow (gas) meters.
Trends in energy consumption	The protocol should take into account wider trends in energy use, so it can disaggregate and isolate the effect of a particular project with enough precision. These trends might include year-on-year improvements in appliance efficiency, electrification and large-scale behavioural factors such as the Covid-19 lockdowns. The use of a control group as part of the evaluation process should be explored as a way to account for these wider trends.
Quality and customer protection	There are concerns in the UK retrofit sector about quality, the trustworthiness of contractors, vendors and government-led schemes, and customer protection from poor implementation. TrustMark and the PAS 2035 standard have helped to address these concerns by codifying and monitoring good practice. Metered energy savings could play a major role in supporting these initiatives and savings can be used to deliver Pay-for-Performance (P4P) efficiency programmes, whereby contractors are remunerated according to savings achieved. The end goal of the metered energy savings protocol should be to form part of the implementation of PAS 2035 compliant retrofits.

Appendix 2: Contributors

The CEEB would like to thank the following individuals who have contributed their time, insights and feedback, in their personal capacities, to inform and strengthen the content of this paper.

Name(s)	Organisation
Chris Jofeh	Advisor to the Welsh Government
Tim Hedgeland; Kate Fielding; Kieron McGlinchey; Clare Lowe	Department for Business, Energy and Industrial Strategy (BEIS)
Shamir Ghumra; Jose Ortiz; John Riley; Jack Hulme; Tamsin McCabe	Building Research Establishment (BRE)
Luke Smith	Build Test Solutions
Murray Birt	DWS
Juliet Phillips (deputy chair)	E3G
David Williams	Economic Consulting Associates
Ian Rigarlsford; Dan Capstick	Ecology Building Society
Randolph Brazier	Energy Networks Association (ENA)
Alex Rathmell (Chair)	EnergyPro
George Simms	Energy Systems Catapult
Molly Webb	Energy Unlocked
Dr Alastair Martin	Flexitricity
Sean Gulliford	Gemserv
Jamie Sivewright	Governex
Emma Harvey; Daisy Bidault	Green Finance Institute
Dr Kerry Mashford, OBE	Interfacing; Chair of the drafting panel for the development of a British Standard for Building Performance Evaluation
Tim Lunel; Adriano Figueiredo	Low Carbon Hub
Sandra Hayes	National Energy Foundation
Russell Smith; Liz Laine	Parity Projects
Aneysha Minocha	Quantenergy
Sam Thomas	Regulatory Assistance Project (RAP)
Soren Nellegaard	RetrofitWorks
Andy Sutton; Matt Kane	Sero Homes
Matt James	Smart DCC
Jon Bootland	Sustainable Development Foundation
Derek Wilson	Transport for London Homes
Prof Tadj Oreszczyn; Prof David Shipworth; Dr Cliff Elwell; Prof Paul Ruyssevelt	University College London (UCL)
Dr Ahsan Khan; Joshua Sykes	Active Building Centre

Appendix 3: Major investor supports metered energy savings

DWS Group is a major asset manager (£696bn in assets under management) and is a member of the Coalition for the Energy Efficiency of Buildings and the Metered Energy Savings working group. DWS published a report last year, "Green, Healthy Buildings as Economic Stimulus", where one of their main recommendations is that a 'digital agenda' for energy efficiency is needed. Their report states that policy makers and the private sector should:

- Measure energy efficiency like the planet, jobs and health depend on it: Ensure the time and location of energy and carbon savings is accurately measured instead of 'deeming' savings.

- Enable energy utilities to start writing procurement contracts for energy efficiency and healthy buildings, creating revenue and stronger financial rigour for retrofit projects.

DWS notes that today, building retrofits are often initially funded by individuals, and/or via a government-led subsidy schemes. This means the efficiency industry is supported largely by a combination of consumer credit and government subsidy, unlike virtually any other part of the energy system.

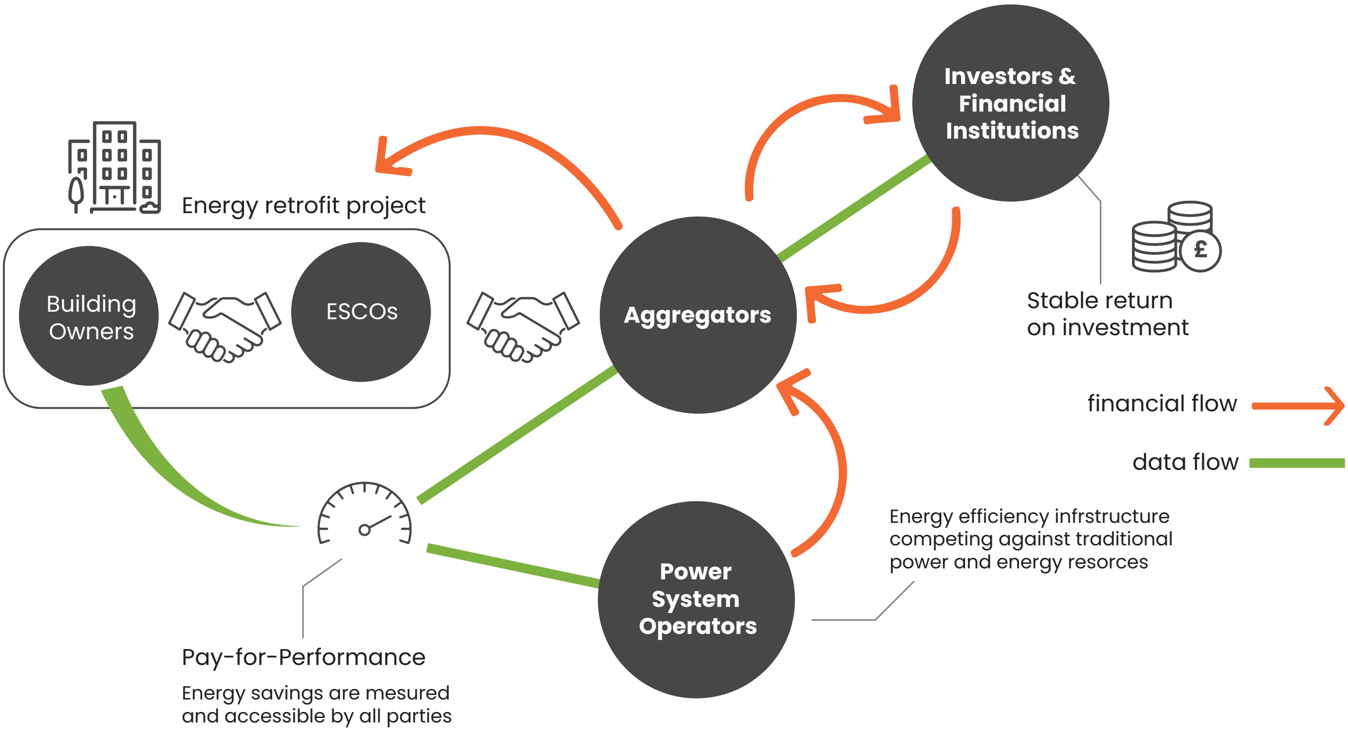
Despite policy makers stating that energy efficiency is a priority for energy policy, currently, electricity supply companies currently cannot invest in or contract for the reduction in electricity use in the same way that they currently invest in or contract for electricity production. Heating supply companies are not able to contract for deep thermal retrofits as an alternative to contracting for imported fossil gas. Energy networks are not able to view energy efficiency as an alternative to expanding network infrastructure.

Utility companies in California and several other US states are changing this paradigm by understanding and then financially valuing how energy efficiency contributes to their requirements to ensure energy security and reduce carbon emissions. These utility companies are creating the first 'pay for performance' contracts with aggregators of residential energy efficiency projects, with payments only occurring if energy is reduced at the desired time and location. By creating contracts for portfolios of energy efficiency projects, a revenue source or cash flow is created.

DWS calls on policy makers, energy regulators, utility companies, project developers and interested financial institutions to help develop Pay for Performance aggregator business models, starting by creating the essential foundation of the 'metered savings' approach.

The potential for payments/cash flow for portfolios of retrofit projects is an important and necessary step-change in the world of energy efficiency. Receiving revenue, not just cost savings is a paradigm shift that will make it easier to convince more families and businesses to retrofit their buildings, cut emissions, improve energy security and air quality and create jobs. Such a paradigm shift would build a market for energy efficiency, not just efficient technologies.

The Energy Efficiency Aggregator Business model



Source: https://www.dws.com/insights/global-research-institute/green-healthy-buildings-as-economic-stimulus/

Disclaimer

Green Finance Institute

CONTACT US

info@gfi.green

greenfinanceinstitute.co.uk