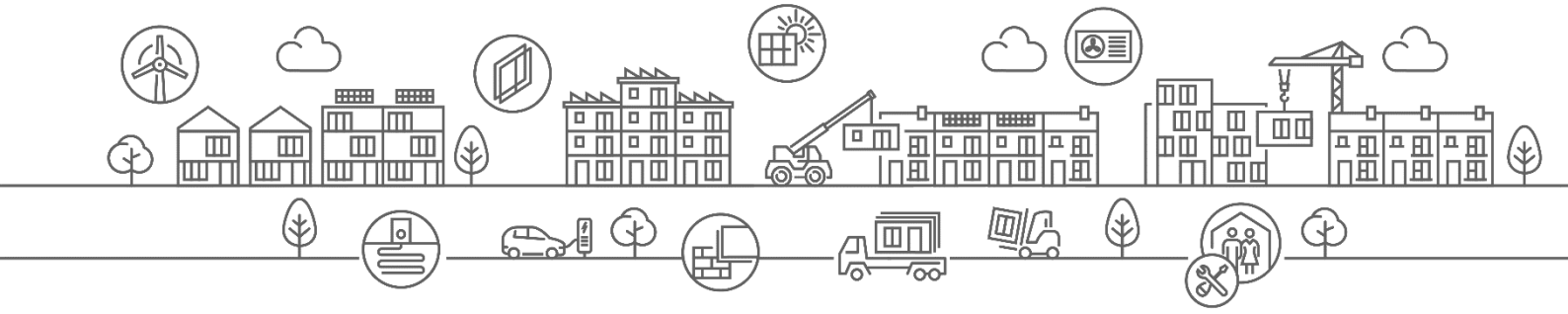
SOCIAL HOUSING RETROFIT ACCELERATOR

Monitoring and evaluation

Toolkit

30th March 2022



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Contents

Summary

This toolkit explains the purpose of monitoring and evaluation in a retrofit project and provides guidance on creating a plan for your project and access to additional resources.

Monitoring and evaluation is required under PAS2035, the standard that governs all retrofit programmes in the UK receiving public funding. Understanding how well your project has delivered the planned benefits is also good practice for any retrofit.

Who should use the toolkit?

The toolkit will help the leadership and retrofit delivery teams understand what impact the installed project measures have on people in their homes, and whether they have resulted in the intended design outcomes. There are no explicit rules for what needs to be considered in a project. The range of performance metrics you choose to monitor may well change each time a new project is planned.

Who is the audience?

The initial audience is the internal delivery team, but the outputs from any reports generated should be fed back to the leadership team to consider how to carry out other projects more successfully in the future. We expect the toolkit to be of most benefit to the Retrofit Evaluator, but the process of monitoring and evaluation includes engaging with all parties - from the resident to the Funding Client.

How should you use the toolkit?

The toolkit has three levels of increasing detail:

- Level 1 – a brief introduction
- Level 2 – a framework for coordinating the evaluation process
- Level 3 – more detailed guidance on how to evaluate the measures, including templates, links to external reports, standards, calculators, and tools.

If you have experience carrying out post-occupancy or building performance evaluation, you may be able to skip level 1.

Recommended process

1. Read the information in Levels 1 and 2 to understand the toolkit basics
2. Take the self-assessment questionnaire to understand progress and areas of strength and weakness
3. Use Level 3 to help develop your own assessment strategy, using the external resources, standards, templates, and reference documents.

NB: In the current release of PAS2035, the Retrofit Evaluator role is carried out by the Retrofit Coordinator. This may change in future versions. References to the Retrofit Evaluator role in this toolkit should be read as referring to the Retrofit Coordinator.

Level 1 – Introduction

Why do we need a monitoring and evaluation process?

Monitoring and evaluation (M&E) of the performance delivered in practice is a key part of any retrofit project. Practical experience has been that there is often a 'performance gap' between what was designed and what is ultimately delivered. This gap means:

- Target project outcomes are not achieved
- Residents are disappointed
- Time and money are wasted
- Carbon savings are not delivered
- The home may even be damaged; for example, by damp, mould and rot because of insufficient ventilation.

M&E of projects has many benefits. It helps identify how successfully a project has delivered its desired outcomes, both for the design and delivery team and the residents. There are also supplementary benefits; for example, seeing which measures have made the most impact for the lowest financial costs, how have they affected the health and well-being of residents, and what lessons can be learned for future projects.

M&E is also a key part of the PAS2035 standard. Complying with this standard is a requirement for any project receiving public funding in the UK, as well as being good practice for all retrofit projects.

What does the toolkit cover?

This toolkit will take you through the steps for designing and delivering an evaluation strategy that will suit any project. It will cover the basic processes, suggest topic areas to consider, point you toward different learning materials, sample survey forms and evaluation techniques and the relevant standards which apply to your project. However, because the range of projects that could be undertaken is so large, it is not a prescriptive project plan.

The toolkit will:

- Help you define a scope for your M&E strategy
- Explain roles and responsibilities
- Help you measure the impact of measures that may be common in a PAS2035 project.

The toolkit is not:

- A mechanical process that produces a M&E strategy automatically
- An exhaustive list of everything that must be considered for your specific project
- A substitute for active discussion by all those involved.

What are the benefits of using the toolkit?

If you are new to PAS2035, it might look daunting. However, this toolkit will help you meet the M&E requirements of PAS2035. It will help you understand the basics of the standard and lead you to external documents, resources and tools that will help you with specific topics.

The M&E toolkit should:

- Enable the internal stakeholders to understand and define the scope of the M&E process
- Allow the project team to select information to gather in the M&E process, and the appropriate way to measure and evaluate their impact on the residents, as well as improvements in carbon emissions
- Help the project team document and report on the findings; both the positive impacts and any accidental negative impacts that need to be documented and learnt from
- Help decision-makers to understand the project, the key issues, and the evidence base
- Provide the basis for learning how to get better results from future projects.

When should you use the toolkit?

Start understanding and using the M&E toolkit as soon as you can. It should be used from the beginning of the project because you will need to:

- Engage with all stakeholders before any design or installation work starts
- Plan any installation of sensors or additional metering
- Continue engaging with stakeholders throughout the project to document the process
- Report on the outcomes.

The M&E process starts as soon as the project begins. You will need to survey the home and residents to assess the current condition of the property and its impacts before work starts. For example, you will want to assess the levels of moisture and damp in a property and its impact on health before any work is carried out, such as replacing fans or other air handling equipment.

Level 2 will give basic information on the fundamental concepts of M&E.

Level 3 will give you more detailed information, resources, tools and templates to help you carry out an effective M&E process.

NB This toolkit is focused on the monitoring and evaluation required by PAS 2035. This covers the technical performance of the installed energy efficiency measures and how they are perceived by the residents. Your retrofit project may have other desired outcomes that you should evaluate as part of your overall assessment. For example:

- Jobs sustained or created
- Apprenticeship or training opportunities
- Impact on Equality, Diversity and Inclusion targets
- Overall impact on sustainability targets
- Broad citizen wellbeing and satisfaction
- Environmental and biodiversity targets

Whilst not a formal part of the PAS 2035 monitoring and evaluation process, it is a good opportunity to capture before and after information on these other important targets, and to include them in the reporting.

Level 2 – Framework for Monitoring and Evaluation

Key Deliverable

The PAS2035 standard specifies that every project must have some level of M&E. The Retrofit Coordinator/Evaluator handles this. Make sure that you have a copy of PAS2035/2030, and that you understand the philosophy and main processes. There is an “Introduction to PAS2035” toolkit and an overview video masterclass.

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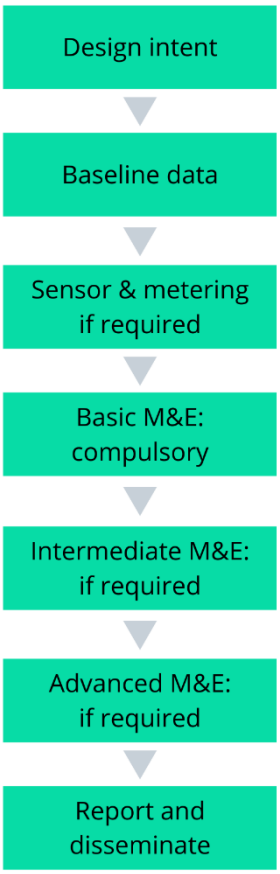
There are three levels of M&E specified in PAS2035:

- Basic (all projects)
- Intermediate
- Advanced.

Intermediate is used when the Basic M&E process reveals problems in delivering the retrofit design outcomes. Advanced is used when there are still unresolved problems with performance after the Intermediate M&E process is complete. Intermediate M&E builds on the work done in the Basic process, and Advanced builds on the work of the Intermediate study.

Basic M&E does not require access to the home. Intermediate and Advanced M&E require access tot eh property and the agreement of the residents.

Key Process Steps



The key stages in the M&E task are:

1. Record the design intent of the project. What were the target outcomes? Where should you focus the M&E strategy to provide the best analysis of the retrofit impacts?
2. Gather baseline data. How did the home perform before installation of energy efficiency measures? This information should be available from the home assessment, design and risk evaluation carried out in PAS2035
3. If additional sensors or metering are to be used, make sure they are included in the design and installation stages of the project
4. Gather post-retrofit qualitative and quantitative data for the Basic evaluation
5. If there is a gap in performance and delivery, extend to Intermediate M&E
6. If there are unresolved issues, extend to Advanced M&E
7. Report and disseminate findings.

Baseline Data

The three levels of evaluation use the same baseline data collected in the preparation phase, before installation work starts. Pre-installation information gathering will include both qualitative and quantitative data:

Qualitative data would include resident's feelings and opinions about how well the building performs. These may include their perception of how easy it is to control the heating and ventilation, whether they systems perform well financially, and whether there are any adverse outcomes on their health and wellbeing because of any inadequate building or design elements.

Quantitative data would include measuring the performance of the building using meters and sensors. This data can then be analysed to check the success of the design, installation and commissioning of the Energy Efficiency Measures (EEMs).

N.B. It is important when collecting qualitative and quantitative data that residents have been properly trained to use any new capabilities or technologies in their homes. Failure to do so increases the risk of poor results, not because the EEMs cannot deliver, but the residents do not know how to take advantage of them.

This is particularly important where new tenants are introduced after the installation is complete and demonstrates why ongoing resident engagement is so vital for successful retrofit projects.

Basic evaluation

Basic M&E applies to all projects and should be delivered within 3 months of project completion. Basic M&E checks whether:

- the desired outcomes been achieved
- there have been unexpected consequences of the work
- the residents are happy with the outcomes
- the client is happy with the outcomes
- the **process** of delivering the project in terms of design, installation, testing, and commissioning was satisfactory.

Also

- What areas could have been improved
- Other feedback from the client and/or residents
- A report which covers all the proceeding points.

Qualitative data will include pre- and post- installation health and wellbeing surveys based on the complexity and scale of the programme of EEMs.

Quantitative data includes collecting previous energy consumption data from bills and using handheld devices to record humidity levels and air quality.

Decision to move into Intermediate evaluation

You may need to move to Intermediate evaluation if:

- Clients have expressed dissatisfaction with the installation process – this could be anything from site materials being stored in an unsafe manner, accidents, excessive noise, or extended installation periods
- Energy bills appear to have gone up, or changed in a way that was not expected
- Clients believe their health or wellbeing has been impacted for some reason
- Fuel poverty has increased.

Intermediate evaluation

Should be delivered between 3 to 6 months after project completion.

Intermediate monitoring checks all the requirements from BASIC, and in addition:

- A review of the report output from the BASIC monitoring
- An inspection of the property to check EEMs are in place and functioning correctly
- Identifying any problematic outcomes of the work
- Collection of metering and sub-metering data that will help evaluate the success of the project – ideally, this should be collected through the heating season
- Collection of other sensor data such as relative humidity, internal and external temperatures
- Checks that any sensors in place for monitoring have not been moved, damaged or otherwise affected
- Resident surveys – while you could choose to use the original survey criteria, it may be wise to ask more detailed questions. This could be around any of the EEMs where the retrofit team feels the outcomes were not as successful as they expected or to respond to issues raised by residents.

The PAS2035 standard recommends post-installation air-tightness testing wherever EEMs have been installed that might affect airtightness, such as window or door replacements, new fans etc. However, because air movement can also have a big impact on mould and condensation, you may carry out air testing where there has been evidence of damp and mould growth.

Qualitative data collection will include reviewing the results of the pre- and post-installation assessments, acting on the findings, and assessing in more detail the root causes of any negative outcomes. This could be through either resident client group meetings or further, more detailed surveys.

Further **Quantitative** data collection might then drill down into more detail on why there were negative outcomes.

- Can more detail be gleaned from the use of sub-metering individual pieces of equipment or heating plant?
- Have all the measures been installed properly?
- Are they being controlled correctly?
- Has a change of resident behaviour led to any increased bills which might not have been accounted for in the evaluation?

PAS2035 also draws attention to the fact that monitoring periods should be extended to include data throughout the heating season to better understand the success of the relevant EEMs. Level 3 covers this in more detail, especially in the sections "**Heat and Insulation EEM analysis"** and **"Thermographic surveys"**.

Information will be collected, analysed, and summarised by the Retrofit Evaluator, who will then create a report including recommendations to the project team and clients.

Decision to move into Advanced evaluation

There are several reasons for extending to Advanced M&E:

- You believe the EEMs are not performing correctly and want to get further insights into why (installation or commissioning errors), or you believe the EEMs may be interacting with each other and causing problems
- Understanding whether the EEM design / Options Evaluation identified the correct measures based on the pre-installation assessments
- The need for a deeper analysis of the thermal performance of insulation or heating plant measures, involving further monitoring over an extended period
- The need for thermographic images to properly understand building performance and/or successful EEM installation
- To understand whether any renewable energy installations are working as expected.

Advanced evaluation

Advanced M&E should be delivered over an appropriate period up to 2 years after project completion. It considers everything in the basic and intermediate evaluations. Also, it is expected to address anything that did not meet the desired outcomes set out in the planning phase and any other negative outcomes and other learnings, and whether they were considered in the design.

It will include a post-construction and post-occupancy review, covering:

- Exactly what was installed
- More detailed surveys to uncover the causes of any health and wellbeing issues, or increases in energy use
- Whether the needs of the residents were met or not, and to what degree – the "**post-installation survey**" document in the toolkit will help you quantify this
- Whether the measures met the retrofit design (and were installed / commissioned to the required contractual requirements)
- Thermographic surveys, where useful
- Monitoring of internal conditions for at least one year
- Sub-metering, including heat, hot water, lighting, renewable energy measures
- Investigation of defects highlighted by the ongoing monitoring.

This more detailed report should explore the issues and deliver learning to all the stakeholders as to the root causes of the sub-standard outcomes. It should also inform any other projects being carried out by the funding client.

Level 3 – Detailed Guidance and External Resources

Roles and responsibilities in the Monitoring and Evaluation process

Annex A of PAS2035 sets out the competency requirements for carrying out M&E. Most responsibilities lie with the Retrofit Evaluator, although other roles will have to provide key information for monitoring.

PAS2035 Roles in the M&E process				
Co-ordinator	**Assessor**	**Designer**	**Installer**	**Evaluator**
PRE-INSTALLATION INVOLVEMENT				
Expected outcomes Budget allocations	Pre-project assessments. Design Specification. Options Evaluation.	Improvement plan Design Specification. Options Evaluation.	Technical drawings. Monitoring equipment installation?	Collating building and resident assessments. M&E strategy.
POST-INSTALLATION INVOLVEMENT				
	Post-project assessments.		Commissioning records. Building regs. Compliance. Handover docs.	
EVALUATION REPORT				
Help define report scope and learning outcomes.	Help define report scope and learning outcomes. Input into the analysis and assessment responses.	Help define report scope and learning outcomes.		Collates, analyses and reports on all data received for the M&E process.

In addition to specific roles within PAS2035, input from other stakeholders will help the Retrofit Evaluator.

Main stakeholder	Their role in the M&E process	Pre-installation involvement in the M&E process	Post-installation involvement in the M&E process
The Retrofit Evaluator/ Coordinator	The Retrofit Evaluator conducts and manages the M&E process. Their primary responsibility is to determine whether the retrofit measures have achieved the desired outcome or require further evaluation.	• Create and distribute the pre-installation questionnaire. • Give clear guidance to the delivery team regarding what the evaluation is and what is needed from them.	• Create and distribute the post-installation questionnaire. • Write the evaluation report and communicate the key outcomes to the relevant stakeholders. • Liaise with the funders in case additional budget for evaluation is required. • Give advice and guidance to the delivery team to improve their performance.
The resident	Resident feedback is essential in assessing whether the project has achieved its intended outcomes. Resident engagement is achieved through pre- and post-installation questionnaires, focus groups, case studies or interviews.	• Fill in the pre-installation questionnaire. • Depending on how ambitious the evaluation process is, the residents may be required to take part in focus groups/case studies/interviews to describe their experience.	• Fill in the post-installation questionnaire. • Depending on how ambitious the evaluation process is, the residents may be required to participate in focus groups/case studies/interviews to describe their experience.
The project funders	Provide budget for the M&E process.	• Alongside the retrofit evaluator, responsible for setting the level of ambition of the M&E process.	• Give their permission if additional budget is required for evaluation.
The project delivery team	Responsible for supporting the retrofit evaluator in conducting the evaluation - collecting data, distributing the questionnaires, sharing ideas on how to complete the evaluation, etc.	• Provide support to the retrofit evaluator.	• Provide support to the retrofit evaluator. • Follow the evaluator's advice and recommendations to improve their performance.

External resources:

- On-demand Masterclass: Role of a Retrofit Coordinator

Planning and designing the M&E process

At its most basic, the process is simple:

- Check what outcomes the project intends to deliver
- Collect before and after data
- Identify gaps between target and delivered performance and find reasons for the differences
- Report on the outcomes.

If M&E reveals desired outcomes have not been met (or only partially met), further interventions may be required to ensure success.

M&E can be a process which lasts for many months. The process starts from the very beginning of the project when dwelling assessments take place. Here, you will collect qualitative and quantitative data that will be used in assessing the positive or negative results of the project.

As soon as the residents have engaged with the project, they will form ideas and opinions about what the desired outcomes are and how they might be delivered, along with potential impacts on the way they live and use their home. They may also be concerned about how the target outcomes, or the delivery process, may impact on their life.

Resources

The Retrofit Evaluator should consider the resources needed for the evaluation during the project planning stage when the budget allocations are being considered.

Budget

- What monitoring equipment will be required?
- Will it be bought or rented?
- Who will pay for it?
- Will there be a cost to aggregating the data; for example, an online monitoring platform?
- How much labour will be required to carry out the engagement surveys?
- How much labour will be required to collect and analyse data and carry out the reporting functions?

Project management

- How much time is available for each part of the process?
- Are there time critical outcomes that need to be considered?

Skills

- Are there trained employees with experience of installing and using monitoring equipment, or might this need to be outsourced to specialists?

- Is there experience in the team of dealing with the data analysis? For example, taking and interpreting thermographic pictures, or will specialist contractors be required?
- What are the implications of managing personal / sensitive data for larger projects? Does your organisation have adequate training in the issues of storage, protection and sharing the data inside and outside the project group?

Evaluation design

The evaluation design identifies the overall **scope** and **critical evaluation questions** of the retrofit impact evaluation.

Scope

The scope defines the scheme elements being evaluated, the timeframe, and the geography. The scope may also identify which issues are to be evaluated and which groups of beneficiaries assessed.

Identifying the key evaluation questions

The key evaluation questions are based on the target outcomes and the EEMs installed. These may be different for the various sub-groups in your target population. Thinking about the different natural sub-groups will help you decide how to focus your evaluation.

Example key evaluation questions for energy efficiency retrofit programmes

- Did the energy efficiency retrofit programme achieve the intended outcomes for the residents?
- Which combination of measures is most strongly associated with energy efficiency improvements?
- How effectively did the retrofit programme contribute to improved building performance?

Focus on what is important

When you are deciding what to monitor and how to evaluate performance, there is no need to measure everything about the building if it is not related to the EEMs. For example, where you are installing ventilation or insulation measures, there is no need to measure water use.

External resources:

- On-demand Masterclasses:
    - Embedding Social value
    - Monitoring and Evaluation

Resident surveys

Gathering qualitative data from residents is a different exercise to the wider resident engagement process but can be carried out at the same time (See Resident Engagement Toolkit).

The resident survey involves collecting opinions and subjective assessments from the residents on their health and comfort, as well as measuring more tangible elements such as temperatures and humidity levels. Engaging residents in pre- and post-retrofit consultation usually happens via questionnaires. Sometimes, resident interviews and focus groups can also take place. The Retrofit Coordinator/Evaluator conducts the resident engagement surveys.

Even if you are asking an opinion on comfort that might normally include words such as 'draughty,' 'stuffy' or 'cold,' you can quantify the answers by asking the residents to put these opinions on a scale of 1 – 10. This then makes it much easier to gauge project success by asking the same questions after the project has completed.

Every survey should be unique and tailored to a specific retrofit project. For this purpose, the Retrofit Coordinator/Evaluator should:

- Define what questions the pre- and post-installation surveys should address
- Decide what information is required from the residents
- Construct tailored questionnaires to deal with specific topics

The list below presents some of the topics that pre- and post-installation surveys can ask the residents about:

- Heating bills
- Electricity bills
- Thermal comfort
- Heating controls operation
- Air quality
- Fans and ventilation operation
- Water use
- Hot water performance
- Lights.

Example questions and survey templates are provided in the pre- and post-installation resident surveys in the accompanying Excel spreadsheet. These are a starter to develop a specific questionnaire for your project.

The **Basic** qualitative study should include:

- A brief questionnaire-based resident interview, covering the following points:
    - Whether the agreed intended outcomes of the project have been achieved

- Whether there have been any unintended or unexpected consequences of the work
- Whether the client and resident(s) are satisfied with the outcomes
- Whether the client and resident(s) are satisfied with the process of assessment, design, installation, testing, commissioning and handover of retrofit measures
- Identification of any specific points of dissatisfaction
- Identification of any elements of the installation that are not working as expected
- Any other comments the client and resident(s) might want to make.

The **Intermediate** study should also include:

- The functionality of the installed EEMs
- The ability of the residents to achieve satisfactory comfort conditions, including temperature and internal air quality.

The **Advanced** study should add:

- Two detailed questionnaire-based interviews with resident(s), carried out with an interval of one year between them.

External resources:

- Report: Affordable warmth & health impact evaluation toolkit
- Report: Resident-centred retrofit: engagement and communication Key Findings: Analysis of a selection of Retrofit for the Future projects.

Monitoring

From Annex D of PAS2035 - “Measures interaction matrix,” it is possible to broadly group the EEMs into five basic categories: Insulation, Ventilation, Heat, Energy efficiency and Renewables. The effectiveness of these measures can be quantified pre- and post-installation using a combination of sensors and metering.

	Sensors	Meters
Insulation	Temperature	Heat / Gas / Electricity
Ventilation	Temperature, Air quality, Humidity, Air tightness	
Heat	Temperature	Heat / Gas / Electricity
Energy Efficiency	Temperature	Electricity / Gas / Water / Heat
Renewables (PV)	N/A	Electricity (generation / export)
Renewables (Solar Thermal)	Temperature	Heat
Renewables (Wind)	N/A	Electricity (generation / export)

Sensors can be installed either temporarily, for the project M&E period, permanently, or simply taken by handheld devices as spot checks at intervals throughout the project. The project size and risk pathway will dictate the most appropriate route for equipment selection, and whether spot checks or installed monitoring is the most appropriate choice.

The benefits of installed devices include:

- Collection of a large amount of data
- Less concern about different people using different sampling methods for measurements, leading to variable data quality
- Less time spent manually inputting data into spreadsheets
- Less chance of human error
- No need to set time aside for site visits to site for data collection
- Online platforms can aggregate data from all your installed sensors and meters in one place
- These platforms may have sophisticated analysis tools that can help report and diagnose unusual readings and automate notifications about these potential problems.

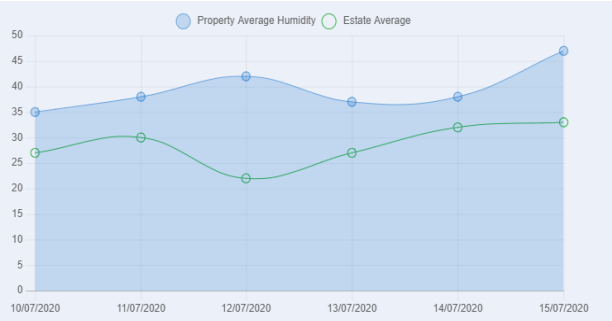
Online monitoring and data aggregation portals

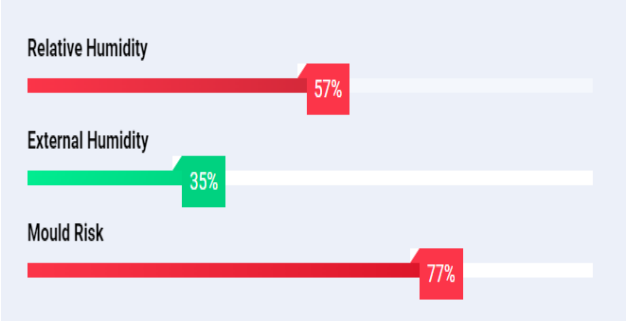
Many companies offer platforms that can help you monitor environmental and energy metrics. They allow you to take a range of information from sensors and meters and view them from one platform.

Typically, these platforms can present graphs illustrating:

- Temperature - and notify when temperatures fall out of defined ranges
- Relative humidity
- Air pressure
- Gas consumption
- Electricity consumption.

When analysed together, this data can provide insights into a range of inferred health and wellbeing outcomes, such as likelihood of increased mould and condensation, fuel poverty or even payback calculations for installed EEMs.





Heat and Insulation EEM analysis

The Basic M&E protocol may not allow for meaningful conclusions about the success of heating and insulation measures. For these, you require a good understanding of heating data analysis and data covering a heating season post-installation.

Instead, the team may consider benchmarking against standard figures. Instead of direct comparative 'before' and 'after', take the 'after' data and compare it to standard figures for similar properties.

There are other situations where you may not see the expected reduction in energy consumption, depending on the weather conditions, the behaviour of residents and when the data is collected.

Example:

You have started a project fitting external wall insulation, removing gas boilers and installing air source heat pumps to a row of terraced houses. In your pre-installation occupation assessments, you asked your residents to supply gas and electricity meter data for a year before the project commencement. The project starts in January and is complete in July.

In the basic evaluation period, you now collect 2 months of post-installation data for your report. However, now the heat pumps have only been providing hot water and there has been no central heating demand at all, given the time of year. Therefore, it is not possible to make any assessment of the success of your insulation or heat pump intervention measures.

If we then consider moving into intermediate evaluation, over a 6-month period – you can gather an extra 3 months of temperature sensor and electricity meter data – but you realise that this has been a particularly warm year, and you still haven't moved into December or January. It's clear that some extra data would be useful, but simply comparing the summer / autumn temperature sensor and electricity meter data you have with the full year of data pre-assessment is going to be challenging.

For this reason, you must consider what will be included in M&E to deliver meaningful learning. This might mean deciding you will use basic evaluation for most of your measures, but the highest impact ones may need advanced evaluation to take data over a more extended period.

Analysing the success of heating and insulation EEMs can be challenging even with a good set of data to work with. Comparing one year of heat meter data with another year of heat data is meaningless if one year was below average in temperature, and the next year was above average. How can we tell if the 10% saving in gas resulted from a more efficient boiler, or just that it was switched on less frequently (or both)? Did the client turn up the room temperature as well?

Various techniques may be employed, such as cumulative sum (CUSUM) and regression analysis using heat meter and 'degree day' data, but these require experience to use with confidence. The External Resources section will point you towards some learning resources on degree day data analysis and best practices for collecting and interpreting your meter and sensor data.

Thermal Imaging surveys

Thermal imaging surveys are usually best undertaken by specialists because it is very easy to misinterpret thermal images without proper training.

Even when you have measured changes in temperature for various building elements, such as a freshly insulated exterior wall, this information might not be much use unless you have a reasonable understanding of analysing heating EEMs.

Thermal cameras will calibrate the colours they use in an image based on the range of temperatures it can 'see' at any one time - so a wall which is coloured purple in one image may be orange in another image from a different angle just 1 minute later. If you are looking for evidence of insulation performance, inexperienced personnel can reach incorrect conclusions. However, relative temperature differences on a façade can pinpoint cold-bridging and damp areas.

If you do not have training in thermography, use specialist contractors. The Retrofit Evaluator should focus on what the thermography is telling them and ensure the specialist contractor is properly tasked to gather the right information. Thermography for building surveys is often best done in the coldest months of the year when the differences in temperature between inside and outside are at their highest.

A brief primer on various aspects of thermal imaging is included in the External Resources, along with training courses.

Evaluation of renewables (e.g. solar PV, wind turbines and solar thermal systems)

Although best practice is to take a fabric-first approach to retrofits, you may also be installing renewable energy sources such as PV, wind turbines and solar thermal hot-water systems. These should be evaluated as well.

Electricity producing renewable energy systems (solar PV and wind turbines) as well as solar thermal systems will perform differently year on year based on environmental factors such as cloud cover and wind speeds. This variability is even higher when considered in smaller time increments – it is possible a system may produce no energy on some days. As such, there is no need to consider a very detailed analysis of their performance. It would be pointless to consider much data analysis within a basic evaluation period given the highly variable nature of the weather.

It is more useful to consider general ongoing benchmarking of performance and making provision for fault notifications than analysing performance over periods of less than a year or years.

Solar PV and Wind

The amount of solar energy falling on a solar system varies by roughly +/- 5% from year to year. Variability in wind generation from year to year or month to month is even higher. Even with a full year

of data, you cannot say with certainty that the result will be higher or lower than 'normal'. Instead, it is better to ensure your monitoring includes automated fault notification so that if the system stops producing energy for a significant period, an automated email warning is generated.

You may also wish to benchmark the month / year performance against what is considered an acceptable range using an online resource such as PV-GIS, Global Solar Atlas or Global Wind Atlas (links in the External Resources section). These online data sets simply predict what happens in a typical year, not the year you installed the measure.

Most solar and wind inverter manufacturers have built-in monitoring facilities with online portals that can completely automate fault detection, drops in yield through power cuts or system failure and generate monthly or annual reports on performance. You should ensure the Retrofit Design makes provision for these services in the procurement process if the Funding Client wishes to monitor performance in the long term. You should also coordinate with your voids team to ensure any new tenants are aware of the systems installed and how to report any faults.

Analysing solar and wind performance is best done by specialists once you have established that there may be an equipment or installation fault that needs addressing (through simple benchmarking or fault warnings generated by the monitoring systems).

Where you have more than one PV system being monitored, it is useful to aggregate the data in one place so that you can compare one system performance against another in the same geographical location. There are some data aggregation portals that monitor the energy generation meter outputs, meaning that you can monitor multiple solar systems installed at different times with different equipment manufacturers, all on one monitoring platform.

Solar thermal

The performance of any solar thermal system is difficult to analyse for three reasons:

- The highly variable environmental conditions which apply to all renewable energy systems
- Resident behaviour in controlling the boiler or other auxiliary heat systems can have a big impact on solar thermal performance
- Different occupation levels in the household can have a big effect.

Solar thermal systems are designed to provide around 90% of the hot water requirement in the summer months for a given occupation level. This drops to around 25% in the winter – giving a typical annual average of around 50%. Where a system may have been designed to provide 50% for a 4-person, 3-bedroom household, if there are significantly more or less people in the household, this percentage will change. We cannot expect a solar thermal system designed for a 4-person household to serve 6 people, even in summer – auxiliary heat will still be required.

Example:

If the boiler is set to come on to heat the solar cylinder at 8am in the summer, the solar thermal system cannot put any solar energy into the store throughout the day if the cylinder thermostat is already satisfied.

Monitoring for simple faults and 'light touch' visual inspection is a realistic method for evaluating whether the systems are performing adequately. To address resident interaction with the measure, make sure an adequate instruction manual in simple and clear language is left with the installation and a client awareness learning session is delivered by the installer. The Microgeneration Certification Scheme (MCS) regulations require that a full handover pack is left with the client, instructing them on issues such as choosing auxiliary heat timings for best results.

Visual inspections can identify leaks, drops in hydraulic pressure and flow rates, which are all adequate for identifying systemic problems that need addressing. Heat meters can be installed but given the highly variable nature of solar thermal performance, they may not yield information that is that helpful in identifying problems.

External resources:

- Report:
  - Thermal Imaging Guidebook for Building and Renewable Energy Applications
  - Guide F Energy Efficiency in Buildings (2012), CIBSE
- Websites:
  - Energy Benchmarking Tool Dashboard
  - Global Solar Atlas
  - JRC Photovoltaic Geographical Information System (PVGIS) - European Commission

Reporting

The report from the M&E study should relate to the target outcomes for the project. It is not just about measuring gas and electricity use. Depending on the scale of the project, the goal might be to create change in several areas:

Resident

- Health and Wellbeing (noise, thermal comfort, air quality, improvement in health)
- Fuel poverty reduction
- Social value.

Client

- Carbon emission reductions (meeting either regulatory or self-imposed targets)
- Renewable energy targets
- Bill reductions

- Compliance (Health and Safety, “Minimum Energy Efficiency Standards for Landlords”).

When deciding on report contents, the Retrofit Coordinator should keep in mind the communication channels typically used by the target group, their level of technical expertise and how much time they have available to look at the materials.

The funding organisation, as well as the delivery organisation, is likely to require a draft report along with a presentation of the main findings before a final report is delivered. The report needs to set out the findings to all the key evaluation questions.

Senior staff in the funding organisation may require a summary document that presents the findings in a visual format, supported by a more detailed report.

When reporting, the Retrofit Coordinator should be honest about the limitations of the findings. If the survey only has a small sample, it should be clearly stated that the evaluation shows correlation rather than causation.

The results should be presented in a form that allows the key stakeholders to assess the project’s success and decide on the next steps. The results might be presented in a report or a verbal presentation.

There are many ways to share evaluation findings, depending on the stakeholders’ preference and the scale of the project. These include:

- Formal detailed technical reports
- Executive summaries
- Presentations
- Webpages
- Newsletters
- Posters
- Public meetings.

For the wider public, a key graphic or an illustrated case study might be more appropriate. Easy read versions which use visuals to illustrate key findings can make evaluation findings accessible to a wider audience.

When we consider energy use, we need to think about how this might change pre- and post-installation at the time of the M&E process design. In a successful project the energy consumption may not reduce as much as expected.

Example:

Your residents have been complaining about a range of health issues including asthma, and condensation problems in the top floor of a block of flats. The Design leads to re-covering and

insulating the leaking flat roof which was causing damp ceilings and walls, installing solar PV and installing heat recovery fans in the top floor flats where this problem has been identified.

We can expect that individual electricity bills will go up in this situation because of the additional fans, but the outcome is an improvement in the health of your residents and an overall lowering of the carbon footprint for the building where this extra energy has additionally been offset by the solar panels. The financial benefit of the solar panels is going to be seen through the 'landlord supply' and accrued by the Funding Client, but we can still consider the overall outcome successful, given the reduction in carbon emissions and improved health outcomes.

Example:

In a high rise building a high proportion of the residents have been complaining they cannot afford to heat the whole flat and have been resorting to turning off the existing high quality storage heaters and using the electric ovens and their own plug-in electric radiators or Butane powered portable room heaters. They are only living in and using one room to save heating the whole flat.

Your programme of EEMs includes replacing glazing and Internal Wall insulation. This leads to a big increase in electricity consumption, but that is because the residents now feel more comfortable in using the fitted heaters – and have abandoned the unsafe plug-in and other portable heating equipment.

External Resources

- On-demand Masterclass: Embedding Social Value

Report template

M&E reports often follow a very standardised format. This table below shows one format for your report to use in a more formal setting such as for dissemination to the retrofit project team and funding client.

Report section	Summary
Executive summary	Present a brief project description and the critical outcomes of the monitoring and evaluation process.
Report contents	
Introduction	Set the aim of the retrofit evaluation report and describe the evaluation elements, purpose and timelines.
Background	Present pre-retrofit property details, energy efficiency improvement measures proposed and reasoning behind the proposed measures.
Methodology	• Present a timeline of the various evaluation activities and their description • Determine the areas targeted with the proposed retrofit solutions, e.g. energy consumption savings, CO_2 savings, improved building performance, etc • Describe the data collection process • Describe the data analysis process • Describe the customer engagement process
Data analysis	• Present survey results, e.g. residents' satisfaction survey • Present comparison data, e.g. internal temperature data pre- and post-retrofit, humidity pre- and post-retrofit, energy consumption pre- and post-retrofit • Covid-19 impact
Conclusion	• Present whether the retrofit programme has achieved its intended objectives • Present key learnings after the evaluation completion • Present any relevant learnings and recommendations • Present any issues/challenges faced during the process • Explain where there is uncertainty about the outcomes and how that might impact on learnings
Appendix	Present supporting evidence and raw data sets.

External resources

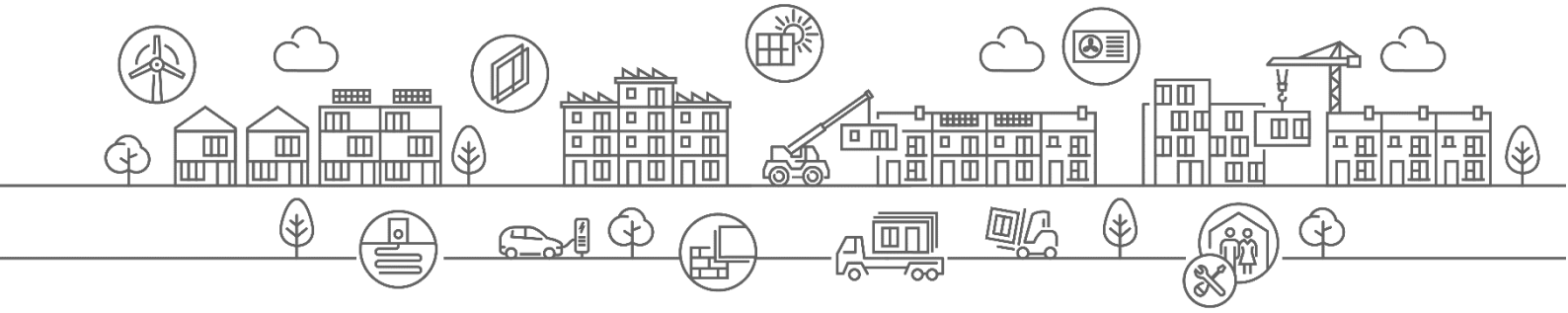
The following list covers additional external material that goes into greater depth in some of the monitoring and evaluation issues.

- Reports:
    - Affordable warmth & health impact evaluation toolkit
    - Home Quality Mark – Assessment and Rating of New Homes
    - Post Occupancy Evaluation and Building Performance Evaluation Primer - RIBA
    - Thermal Imaging Guidebook for Building and Renewable Energy Applications
    - Guide F Energy Efficiency in Buildings (2012), CIBSE
    - The 'Most Significant Change' technique – a guide to its use
- Websites:
    - JRC Photovoltaic Geographical Information System (PVGIS) - European Commission
    - Global Solar Atlas
    - Global Wind Atlas
    - EQ-5D – Healthcare Decisions
    - Degree Days – an Introduction
    - How to Calculate or Prove Energy Savings Using Degree Days and Regression
    - Energy Benchmarking Tool Dashboard
- On-demand Masterclasses: Social Housing Retrofit Accelerator
- BSI Standard: PAS2035/2030:2019 Retrofitting Dwellings for Improved Energy Efficiency. Specification and Guidance
- Case Studies: Dartford Housing Retrofit Project Evaluation Report
- Training providers:
    - Energy monitoring and targeting
    - Building services and engineering
    - Thermal imaging training

SHRA Toolkits available online

The full selection of SHRA Toolkits are available at:

www.socialhousingretrofit.org.uk/knowledge-hub



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