



Department for
Business, Energy
& Industrial Strategy

Evaluation Plan for the Whole House Retrofit Competition

Final Report to the Department for Business,
Energy and Industrial Strategy

June 2020



OGL

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1. Introduction

Through the Department of Business, Energy and Industrial Strategy's (BEIS) Energy Innovation Support Programme (EISP) contract, delivered by a consortium led by Mott MacDonald, Technopolis Ltd were commissioned to develop an Evaluation Plan for the Whole House Retrofit (WHR) programme. The WHR programme is part of BEIS' Energy Innovation Programme, which aims to accelerate the commercialisation of innovative clean energy technologies and processes into the 2020s and 2030s. This plan will help build an understanding of the likely scope and scale of work required for the evaluation, and inform BEIS decisions around its future commissioning.

This draft final report sets out the findings of the evaluation plan scoping work completed by the EISP consortium between February and June 2020 to develop an evaluation plan. The report is structured as follows:

- **WHR project background** – including its rationale, aims and objectives, commissioning, and implementation progress (**Section 2**)
- **The programme and project level theories of change** (**Section 3**)
- **Evaluation purposes, levels and questions** - this section examines stakeholder requirements and evaluation purposes, and a prioritised list of evaluation questions (**Section 4**)
- **Research methods and data collection** – this section describes the suggested methods and data needed to meet the evaluation objectives (**Section 5**)
- **Evaluative and analytical approaches** – this outlines the specific evaluative and analytical techniques applicable to this study (**Section 6**)
- **Estimated evaluation costs and timelines** – this sets out the budget assessment and evaluation timelines (**Section 7**)

2. WHR Project Background

Underlying context and the rationale for intervention

To fulfil its 2008 Climate Change Act commitments and the Net Zero target, the UK will need to almost completely decarbonise energy use in buildings by 2050. However, by 2050, most buildings in use will have been built before 2020 and therefore will require some form of retrofitting to enable this decarbonisation. Precise levels of retrofitting required will be dependent on the successful roll-out of green electricity and hydrogen heating and power sources across the country. Consequently, BEIS has launched a number of strategies to help reach these targets. In May 2018, the UK Government launched the Buildings Mission to halve energy use of new buildings by 2030, as well as halving the cost of reaching the same standard in existing buildings.¹ An additional consideration is the 2015 Fuel Poverty Strategy which set a target of bringing as many fuel poor homes as practicable to EPC band C by 2030.²

There is already a good understanding of how to install single retrofitting measures or partial house retrofitting measures in multiple properties, and there is knowledge of undertaking whole house retrofitting (WHRs) of individual properties. However, the costs of individual WHR are currently high and there has been limited commissioning of WHR at scale which might offer economies. As a result cost saving innovations, business models and approaches have not yet materialised and there is a need to create a new WHR market with suppliers who can overcome barriers such as an underdeveloped supply chain, a lack of business models that are focused on cost reductions for different types of housing stock, and a lack of process innovation. Consequently, projects like the WHR competition are needed to create opportunities for innovation in this area so that barriers can be overcome and progress towards meeting the Building Mission and Clean Growth Strategy and contributions to the Fuel Poverty Strategy can be expedited.

Previous public projects have explored solutions to large-scale whole house retrofitting (WHR). Examples include:

- *Retrofit for the Future (2009-2014)*: this £17m Technology Strategy Board programme looked to retrofit over 100 UK homes, achieving an 80% reduction in in-use CO₂ emissions. The project found that key to effective retrofitting was detailed project planning, effective management and co-ordination on site, a well-developed supply chain, and working closely with the supply chain. The programme also emphasised the need for a thriving retrofit market in the UK.³
- *Scaling up Retrofit*⁴: a follow-on programme to Retrofitting for the Future, Scaling up Retrofit funded research into delivering retrofitting more cost effectively. It focussed on

¹ <https://www.parliament.uk/business/publications/written-questions-answers-statements/written-question/Lords/2018-10-22/HL10882/>

² HM Government (2015) *Cutting the cost of keeping warm – a fuel poverty strategy for England*, p. 20. Available https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/408644/cutting_the_cost_of_keeping_warm.pdf, p.20

³ Technology Strategy Board (date unknown) *Retrofit Revealed: The Retrofit for the Future projects – data analysis report*. Available at <https://retrofit.innovateuk.org/documents/1524978/2138994/Retrofit+Revealed+-+The+Retrofit+for+the+Future+projects+-+data+analysis+report/280c0c45-57cc-4e75-b020-98052304f002>

⁴ No information available on programme budget or timescale

the re-working of surveys and specifications, new supply chain management processes, customer-focussed business models, and lower-cost energy monitoring processes.

- *Thermal Efficiency Innovation Fund (2018-2021)*: this £10m grant scheme looked to improve the energy efficiency of existing UK buildings through the use of innovative technologies, processes and business models. It awarded grants to 12 projects with a total value of £7.5 million. Two projects had a retrofitting focus: the Sustainable Traditional Buildings Alliance's Whole House Retrofit (for 30-40 homes) which introduced new surveyor training and a new toolkit for industry use; and Vestimi's Retrofit Optimisation with Radbot (ROWR) which looked to introduce new energy saving monitoring methods.⁵
- *Energy efficiency improvement rates – local supply chain demonstrators (2018-2021)*: this provided £1.2m of funding across six pilots, each of which looked to tackle some of the supply side problems (e.g. skills shortages, lack of awareness, poor networks of suppliers and contractors) that prevent consumer take-up of WHR.⁶

Each of these projects has or is producing relevant and useful evidence and insight into whole house retrofit strategies. However, they still leave unfilled gaps, requiring further intervention. Firstly, each of the projects implemented a variety of delivery models and policy makers are keen for greater clarity on which ones are most effective. Furthermore, the Thermal Efficiency and Innovation Fund and local supply chain demonstrators may have some relevant WHR solutions, but lack the scale needed to ensure that the UK meets its 2030 targets. Hence, one of the WHR programme's goals is building on and scaling up this previous work as well as dovetailing existing BEIS activity in the area.⁷

The Programme

In light of the issues raised above, in May 2019, BEIS launched the Whole House Retrofit (WHR) Programme. The £9.4 million WHR competition funds a small number of projects which aim to demonstrate cost reductions in whole house retrofit - and aim to accelerate a reduction in domestic retrofit costs nationally. The programme's emphasis is on mass production and large-scale delivery through a combination of process related innovation and housing fabric retrofits. BEIS expects each WHR project to generate the following key outputs⁸:

- Demonstrate cost reduction through process innovation
- Evidence sources of cost reduction
- Improve at least 75 homes per project

⁵ BEIS (date unknown) *BEIS Thermal Efficiency Innovation Fund – Summary Project Details*. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/825631/BEIS_Thermal_Efficiency_Innovation_Fund_summary_project_details.pdf

⁶ BEIS (2019) *Selected demonstration projects: summaries*. Available at <https://www.gov.uk/government/publications/energy-efficiency-improvement-rates-local-supply-chain-demonstration-projects/local-supply-chain-demonstration-projects-summaries>

⁷ E.g. the grant programme of support to coordinate the supply chain for retrofit at a local level (see https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/741974/Grant_Call_Retrofit_Supply_Chain.pdf), and an international literature review of WHR practices

⁸ BEIS (2019) *Guidance: Whole House Retrofit (WHR) competition*. Available at <https://www.gov.uk/guidance/whole-house-retrofit-whr-competition>

- In each retrofitted home, bring down heating energy usage down to at least 30kWh/m²
- Improvements to health, wellbeing and comfort of occupants.

BEIS also expects each project to develop a retrofit plan, install a WHR according to these, commission implementation with residents, and introduce post-installation monitoring.

BEIS application guidance has highlighted that projects are likely to focus on social housing – they most easily meet the requirements for covering a large number of dwellings, uniformity in dwellings, and the long time horizons that social landlords focus on in their investment decisions. However, BEIS also signalled its interest in a mixed tenure approach – welcoming proposals that included privately owned properties.

Grant competition

BEIS ran the programme as a competition resulting in grant awards. The process began with a suppliers' event. BEIS used this to understand interest levels and to gain feedback on energy efficiency ambitions for the programme. Following this, BEIS decided to scale-back both the energy demands and the required number of homes to be retrofitted in each project.

Following this event, BEIS issued an open call for applications, accepting bids from any organisation or consortium able to meet the expected outputs listed above. All successful bidders were required to have access to a large number of similar properties which could be whole house retrofitted within the project timeframe, and also be able to leverage third-party funding. Each applicant completed an application form, asking for basic details about the projects and type of WHR planned, how the proposal met competition objectives, the appropriateness and credibility of the project plan and timescales, proposed dissemination strategies for study findings, skills and expertise, and project costs.

BEIS received eight applications covering a range of housing archetypes including terraced and semi-detached homes. Three assessors from a pool of eight assessed each application, scoring the projects based on their application form content, followed by a moderation process. Three applications did not meet the minimum threshold while of the remaining five, four were successful.

The awarded projects

The WHR competition has awarded funding to four projects, all of which should complete installations by March 2021 to enable project completion by September 2021. Total eligible project costs have ranged from £4.2m to £9.0m with the total value of BEIS WHR grant requested ranging from £1.1m to £3.5m. There is also a large range in the number of dwellings included in each project: 75-195.

Specific details on each project are not available but brief summaries of each project's remit and the work involved are included below: **[Please note – BEIS to replace these summaries with their own versions when they are ready to do so].**

- **Project A:** this focuses on 75 terraced houses based in London and another UK city. The lead applicant is a city council but partners also include a housing association, a consultancy specialising in property, and an energy efficiency analytics organisation. The project aims to demonstrate a cost reduction of 5% per unit is achievable through an increased scale of deep retrofit, while also delivering energy savings and improved comfort and health outcomes for residents. Operating from July 2020 to December

2021, the project uses an established retrofit standard consisting of the installation of prefabricated panels to the front and rear of terraced properties including triple glazed windows and high performance doors), external wall insulation, underfloor insulation, and the introduction of mechanical ventilation with heat recovery.

- **Project B:** this involves 100 homes in a town in Scotland. A county council was the lead applicant but other partners include an architecture firm and a construction consultancy. The project's main aim is to demonstrate cost reductions in retrofitting that would enable mass-market scale-up in the UK. It is also especially keen to deliver warm and comfortable homes that are also affordable to heat. Operating between December 2019 and September 2021, the project aims to bring about 12-13% cost reductions through the use of strong survey processes, iterative installation approaches, off-site manufacture, and replicable design solutions.
- **Project C:** this project is based in a rural county in England and aims to demonstrate the installation of a whole house retrofit package in 100 council-owned social houses. A county council was the lead applicant with partners also including an energy consultancy and a private estate. The emphasis is on providing a replicable WHR model that provides a model for addressing fuel poverty and climate change in a rural region. This project is looking to achieve a 5% cost reduction on an existing WHR model through bulk purchasing of labour and materials, lower coordination costs, and lower per property monitoring and evaluation costs. The new WHR model also needs have net zero energy requirements over a year, a 30-year performance and maintenance guarantee, and be installed in less than 15 days.
- **Project D:** this is a London-based project working on 180 homes and looking to make them ready for 2050 energy standards. Its lead partners are a city council, and a consultancy specialising in property. Running from October 2019 to September 2021, the project consists of two work streams. One delivers the 2050 standard homes immediately through deep retrofit through fabric improvements, a consideration of airtightness and ventilation, generation and renewables. A second workstream instead focuses on delivered 2050 standard homes on an incremental basis (e.g. through solid wall insulation, underfloor insulation, ventilation, controls and balancing heating). Through these approaches, the project hopes to achieve a total cost reduction of 26% per home based on baseline costs though if market demand increases the scale of operations to 1,000 homes per year, then 50% cost reductions by 2025 may be achievable.

Project Monitoring

A Monitoring Officer (MO) oversees each project, keeping track of progress made. They currently communicate with their project leads on a monthly basis. Once projects are operational, MOs will carry out monthly calls, and undertake quarterly site visits. Each project must also produce a monthly monitoring report, plus quarterly and annual monitoring forms that include details of progress made, risks, and costs. Each project also has a bespoke milestone schedule.

The BEIS SICE (Science and Innovation for Climate and Energy) directorate has its own KPIs (Key Performance Indicators) which it expects all relevant Energy Innovation Portfolio (EIP) projects and programmes to collect (**see Annex 1**). As yet, BEIS and programme stakeholders have not decided precisely how each project will report on each of these but have established

some broad guidelines. BEIS requires all grant recipients to build in project data collection and reporting requirements for all relevant BEIS Energy Innovation Portfolio KPI Performance Metrics – using BEIS' Project Data Collection and Reporting Template and the Standard Methodology Guidance. Project teams will have to complete the Template both at the project's start and end, reviewing periodically. A BEIS Project Officer will review and quality assure the final monitoring submission.

3. Programme and project level Theories of Change

This section sets out programme and project level Theories of Change as well as summarising expected programme and project level benefits.

Theories of Change

Theories of Change (ToC) are ‘causal’ maps that aim to reveal the inner workings of a programme, showing how different programme elements are intended to help achieve outputs and outcomes. Causal maps and theory-based approaches more generally are particularly helpful when there is an intention to:

- focus on modelling specific programme aspects – helping bring focus for the evaluation on key causal processes within a programme. In the case of WHR the particular focus is on cost reduction mechanisms, and the potential consequences of achieving WHR at reduced costs through these projects.
- use the findings to determine wider implications, the replicability, or generalisability of an evaluation’s findings.

We have developed both programme and project level (causal) ToCs. Although the programme and respective projects share similar objectives and aims, the activities and impact pathways vary at these two levels. Developing separate ToCs at these two levels makes it easier to map and understand what is expected to happen at these different levels. Later in this report we set out the different evaluation questions that are relevant at programme and project levels.

Our approach mapping assumes that for most energy and climate change programmes, there is likely to be a key ‘output’ (for example the uptake and use of energy efficiency measures, or behaviour changes in key stakeholders). Achieving each output requires overcoming a range of specific barriers and obstacles, or triggering certain ‘enablers’. Once the main output has been achieved, this in turn creates the potential for a range of different outcomes.

Our approach to ToC differs in a number of ways from ‘logic models’ which evaluations often use as the basis for cost benefit analysis. Logic models typically list all the inputs, outputs and outcomes that a programme intends to deliver to better understand the various components of an intervention that need measuring. In ToCs however, there is a clear focus on determining the causal relationships between key programme elements.

Given that the study took place in the programme’s infancy, we have developed the project level ToC in the absence of detailed project-level information, and with no engagement with representatives of the projects themselves. We therefore recommend revisiting the ToC during the evaluation’s inception phase, producing bespoke ones for each project to account for contextual variations and thus varying models and pathways. The evaluators should refine both the programme and project level ToCs over the course of the evaluation.

Causal analysis

While the projects individually are relatively simple (especially when compared to other energy and climate change programmes), the whole programme itself is a complex one. With each project adopting a different WHR implementation approach, the programme is unlikely to see a predictable pattern of cause and effect. Each project is likely to use different sources of cost reduction, having varying levels of interaction with local markets and other initiatives, and potentially generating different medium and longer term outcomes. Consequently, analysing cause and effect within the whole WHR programme is unlikely to be straightforward.

We suggest that the analysis of the programme's causal processes should use a broadly realist lens. This means focusing on examining the 'generative mechanisms' underlying change. Under 'generative causality,' realists recognise that interventions 'a', or 'a' and 'b' can increase the likelihood of 'y' happening but they do not accept that 'a' can always be expected to cause 'y', because contextual factors and 'agency' (free will) can influence whether and how causal mechanisms work in practice. Realist causal analysis also embraces concepts such as equifinality (that there may be other ways of achieving y - in both similar or different contexts) and 'multifinality' (that the same interventions or 'causal forces' can generate different outcomes in different contexts).

This contrasts with positivist and deterministic notions of causality⁹. These perspectives tend to assume that 'a' will cause 'y', or that 'a' and 'b' will cause 'y' if a set of assumptions hold, and they pay very little attention to the role of context and human agency in generating causal explanations. Rather than looking at causal processes, positivists and deterministic approaches use a 'successionist' logic of causality for drawing causal inferences – this relies on regularly observing differences in outcomes between cases that are and are not exposed to 'causal forces,' rather than looking at causal processes as per generative causality approaches.

These themes are key in understanding the nature of causal relationships inherent in any ToC. They will also need to underpin the causal analysis and explanatory accounts that the evaluation generates. The realist perspective – highlighting the importance of context in causal relationships, further supports the rationale for undertaking project level and full programme evaluations to help fully understand how the WHR competition has worked.

Programme level Theory of Change

Figure 1 below provides the programme level ToC and shows how through BEIS funding, these WHR projects are expected to contribute to a reduction in WHR costs, and how these cost reductions will be evidenced. It then illustrates how the improved evidence base is expected to create greater confidence and greater viability of future WHR projects, and also how these future projects should lead to further cost reductions. The programme level ToC includes the monitoring and evaluation processes themselves as they play a critical part in achieving the intended outcomes and impacts.

⁹ These kinds of approaches tend to assume that a will cause y, or that a and b will cause y if a set of assumptions hold, and they pay very little attention to the role of context and human agency in generating causal explanations. They tend to invoke a successionist or counterfactual logic of causality which relies on regularly observing differences in outcomes between cases as the rationale for drawing causal inferences rather than looking at causal processes.

Figure 1 Programme level theory of change (PGs¹⁰ are reference numbers for each part of the ToC)

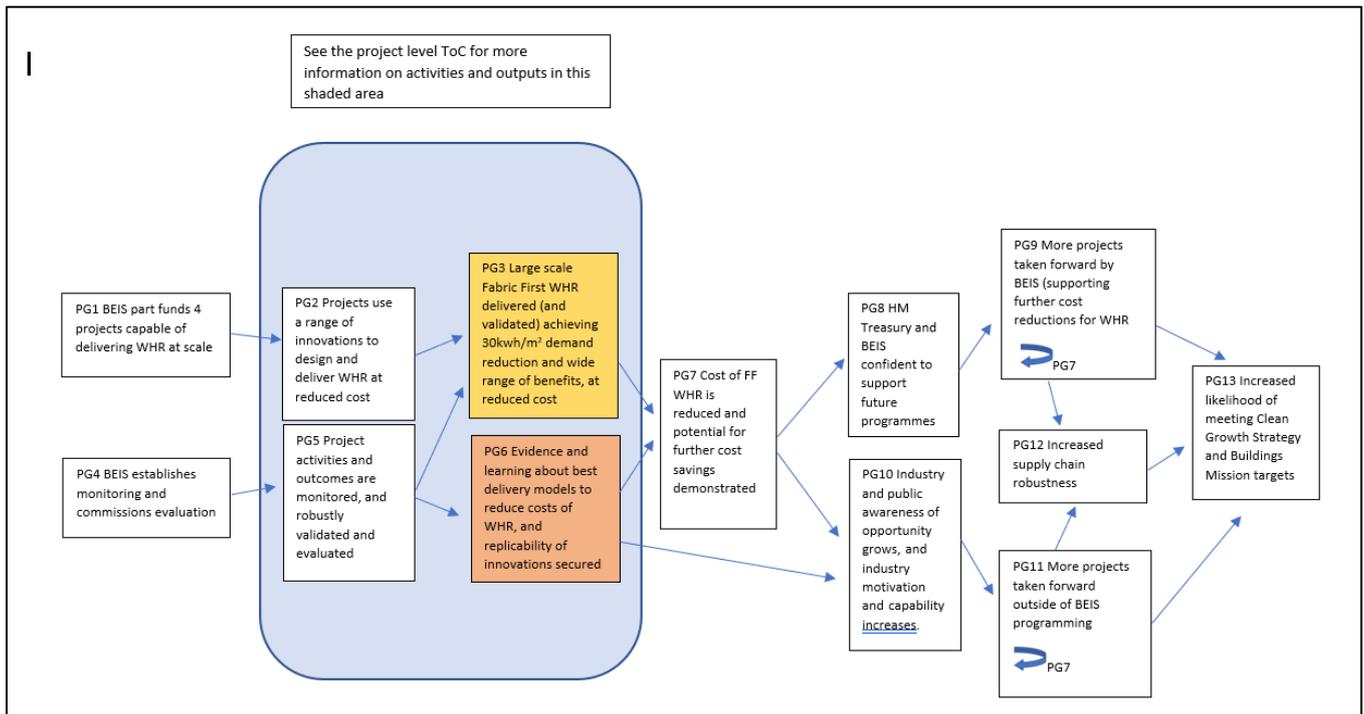


Table 1 provides further details of the key individual components of this programme level theory of change, and the assumptions underpinning the causal processes involved.

Table 1 Components of the programme level theory of change

Component	Further details	Assumptions
PG1 BEIS part funds 4 projects capable of delivering WHR at scale	<p>BEIS launched the programme in June 2019 running a competition to identify a number of projects capable of delivering WHR at scale. The competition made available £9.4m of funding for projects to demonstrate cost reduction in the deep retrofitting of dwellings. Project applications were submitted in August 2019, with four receiving funding.</p> <p>The rationale for Science and Innovation for Climate and Energy (SICE) directorate funding is that this project is funding the cost of innovation and demonstration rather than deployment. BEIS funding covers up to 40% of project funding, with the remainder being match funded (although there were no restrictions on using funding from other BEIS schemes such as Renewable Heat Incentive).</p>	<p>Given the rapid project progress required, it is likely that some of the projects were already planned (though these are likely to have been conceived as smaller in scale). For these projects, BEIS funding may have contributed to the scale, pace and timing of projects (i.e. the projects are delivered sooner than would otherwise happen).</p> <p>We also expect BEIS funding to have contributed significantly to the focus on cost reductions, demonstration effects and evidence generation.</p>

¹⁰ the prefix PG stands for programme, helping differentiate with elements of the project level ToC.

<p>PG2</p> <p>Projects use a range of innovations to design and deliver WHR at scale at a reduced cost</p>	<p>Projects submitted ideas for fabric first WHR delivery models that would meet the programme’s aims and objectives. WHR delivery costs are typically high so this programme’s main ambition is to demonstrate the feasibility of cost reductions.</p> <p>BEIS anticipated innovations in a) the approach to WHR design (e.g. new ways to bring together multiple components of WHR or involving stakeholders in design), b) product innovation (e.g. new materials, technologies or new ways of using existing materials) and c) innovations in business processes (procurement, project management etc).</p> <p>The project level ToC sets out the actual innovations that are proposed.¹¹</p>	<p>Specific assumptions can be identified for the project level theories of change</p> <p>A wide range of external factors could affect the ability of these innovations to achieve their objectives (especially economic shocks or fluctuations affecting prices).</p>
<p>PG3</p> <p>Large scale WHR delivered (and validated) achieving an energy performance of 30 kWh/m2/yr and a wide range of benefits at reduced cost</p>	<p>The programme targets an improvement to approximately 200 homes (at least 75 per project) by March 2021. The WHRs must be delivered with a cost reduction (to the commissioner) of between 5-20%.</p> <p>We know that WHR measures to be deployed include:</p> <ul style="list-style-type: none"> • Over-cladding and additional external walls • Replacement of windows • Over-cladding of roofs including photovoltaic panels • Underfloor insulation and heating <p>BEIS has stipulated that each project must achieve at least a 30 kWh/m2/yr performance improvement as part of an appropriate ‘fabric first’ approach. Performance must be assessed through pre-and post-retrofit tests for at least a random sample of homes. Assessments must include technical performance of measures, occupant experiences (health, comfort and well-being) and unintended consequences; and any mitigation actions must be taken.</p>	<p>It is assumed that resident engagement enables recruitment and delivery schedule to progress at the rate anticipated.</p> <p>We assume that cost reductions should be achieved through real changes in the design and delivery of innovation solutions, rather than simply reducing profit margins.</p> <p>Potential risks to delivering the main output (not already mentioned) include: any delay in reaching legal agreements about grant conditions; delay in approval times from external bodies and planning approval; extreme weather conditions, loss of funding, supply chain issues; EU exit issues (resulting in difficulties accessing labour, materials and component parts), other unforeseen practical / technical issues</p>

¹¹ As documented in their applications or based on scoping interviews with Monitoring Officers.

	<p>BEIS does not have a particular housing archetype preference but buildings must be three storeys or under, or under 18 meters in height. Projects should only include homes that have a low EPC rating (below C).</p> <p>Projects will need to build on initial high-quality engagement with residents. As the projects progress it will be important to minimise disruption, ensure that residents are informed of progress etc.</p>	
<p>PG4</p> <p>BEIS establishes project level monitoring and commissions the overall evaluation</p>	<p>Project monitoring and evaluation is essential for a) performance management and b) ensuring the projects can evidence the source of WHR cost reductions. Monitoring Officers (MOs) oversee the monitoring of one or more projects each. Each project has a bespoke milestone schedule, plus quarterly and annual monitoring forms which include details of progress made, risks, and costs. Projects also produce a monthly monitoring report. The MO has regular meetings with the projects to assess progress against project plans, and quarterly site visits.</p> <p>Projects themselves are required to define their own approach to monitoring performance and outcomes. However, full details of these were not available for this study (see PG5).</p> <p>Programme wide KPIs are based on the SICE KPIs (see Annex 1: List of potential KPIs) which will be common across the projects.</p> <p>Robust evidence is critical to achieving the longer-term project objectives of inspiring continued investment in WHR (both public and via industry).</p>	<p>We assume that projects will establish proportionate and effective project level monitoring which the evaluation can also draw on.</p> <p>We also assume that BEIS will commission an evaluation early on in the programme to enable evaluators to involve the projects in the evaluation (i.e. early enough in as soon as possible to enable early arrangements to be made with projects for participation in the evaluation development of project level theories of change, informing detailed data collection, agree standardised resident and performance outcome measurements).</p>
<p>PG5</p> <p>Project activities and outcomes are monitored, and robustly validated and evaluated</p>	<p>As the projects develop, Monitoring Officers check project progress. Each project is also establishing its own internal monitoring systems – e.g. onsite monitoring by quantity surveyors, and accreditations of finished works by external organisations.</p> <p>Projects must report on key outcomes using pre-and post-installation measurements across a variety of measures including:</p>	<p>We assume that projects will develop their plans and start to pilot and implement pre-installation measurement systems soon after contract award.</p>

	<ul style="list-style-type: none"> • Energy efficiency, air tightness, pressure and ventilation • Energy demand • Costs to residents • Resident comfort and satisfaction • (Likelihood of) positive health outcomes <p>In their applications, projects proposed output and outcome measurement approaches. The MOs will validate these with programme evaluators also using the data.</p> <p>Projects also need to report on the sources of cost reductions as part of a wider end of project report.</p>	
<p>PG6</p> <p>Evidence and learning about best delivery models to reduce costs of WHR, and replicability of innovations secured</p>	<p>Through monitoring, project reporting and the evaluation, BEIS expects to secure reliable evidence about a) actual cost reductions and b) the sources of cost reductions. The evaluation will need to trace and validate evidence of the sources for these cost reductions.</p> <p>Cost baselines and comparator data might also be obtained from other recent and / or concurrent WHR projects such as Innovate UK’s Retrofit for the Future¹², the Mayor of London’s Energy Leap¹³, London’s Retrofit Accelerator¹⁴, Accelerator cities pathfinder¹⁵ and Nottingham’s deep retrofit project.¹⁶</p>	<p>It is unlikely that BEIS would have gained evidence and learning about the sources of any cost reductions had it not been a key project partner. We assume that access to data and evidence for evaluators has been agreed as part of grant conditions.</p> <p>Bidders had to provide (robust and credible) evidence of current costs of WHR to demonstrate the baseline for measuring the cost reduction. Projects must also include evidence in their project completion reports on the sources of cost reduction – something we assume is a grant condition.</p>
<p>PG7</p> <p>Cost of WHR is demonstrably</p>	<p>A national outcome of these local projects is that by delivering WHR at a reduced cost, these costs then become important</p>	<p>This outcome depends on both the project delivering the expected cost reductions, and the</p>

¹² <https://retrofit.innovateuk.org/>

¹³ <https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/energy-leap-project-pilots>

¹⁴ <https://www.london.gov.uk/what-we-do/environment/energy/retrofit-accelerator-homes>

¹⁵ <https://www.ukgbc.org/ukgbc-work/accelerator-cities-pathfinder/>

¹⁶ <https://www.energiesprong.org/projects/nottingham>

<p>reduced and potential for further cost savings illustrated</p>	<p>benchmarks for assessing / estimating future project costs.</p> <p>Projects have to provide commentary based on their project results on where further cost reductions could be achieved (for similar WHR projects) including a cost reduction trajectory of 50% by 2030. The evaluation will need to produce similar estimates using data from all the projects as well as wider evidence.</p> <p>Taken together, evidence on cost savings (both potential and actual) could be used along with analysis of existing housing stock data to assess the applicability of the WHR innovations at scale and the likely scale of achievable cost reductions. This may inform the development of a road map to national deployment at scale.</p>	<p>generation of rigorous evidence about processes and outcomes.</p> <p>There is greater likelihood of achieving and sustaining this outcome if other comparable projects (i.e. those listed in PG6) have also helped to reduce costs. This would of course mean that any observed sustainable cost reductions could not be attributable solely to the WHR project.</p> <p>There is a feedback effect on cost reductions (PG7) from PG 9 and 11.</p>
<p>PG8 HM Treasury and BEIS confident to support future WHR programmes</p>	<p>If the programme demonstrates that cost reductions are achievable, BEIS will be in a strong position to make the funding case for for future WHR programmes. Future programmes might expand the scale of work or include a more diverse portfolio of housing tenures and housing archetypes, helping deliver yet further cost savings. We anticipate that costs will need to continue to significantly fall before a self-sustaining market can exist.</p>	<p>Assumes the programme is successful and that some or all of the projects demonstrate the anticipated cost reductions. It also assumes there is good evidence that further cost savings are achievable.</p>
<p>PG9 Future BEIS programmes support further cost reductions for WHR</p>	<p>Future programmes are commissioned, each programme uses evidence and learning from other / previous programmes to further lower costs. Technological improvements, better materials, and production at scale will likely bring costs down further.</p>	<p>Assumes previous programmes are successful in demonstrating cost reductions</p>
<p>PG10 Industry and public awareness of opportunity for WHR</p>	<p>Appropriate publication and dissemination of findings (by BEIS and projects), may help generate wider interest in WHR amongst both the public and industry.</p> <p>This should help improve the chances of other projects being taken forward outside of</p>	<p>Growth in awareness and interest is likely to depend on the findings (scale of cost reductions and wider benefits), and the reliability of the evidence generated</p>

<p>grows, and industry motivation and capability increases.</p>	<p>BEIS programming, particularly in similar circumstances, but also with other housing archetypes, in other tenures (private) and in other sectors (e.g. non-domestic market).</p> <p>More information on the nature of proposed dissemination activities is set out in PJ21.</p>	<p>(PG6) and the quality of dissemination (PJ21)</p> <p>Industry and public awareness and interest in WHR for other tenures (private rented sector and owner occupiers) and other property archetypes would depend on the transferability of cost savings to these different contexts – such transferability is not assumed.</p>
<p>PG11</p> <p>More WHR projects taken forward outside of BEIS programming</p>	<p>Actors outside of BEIS programming and innovation funding streams initiate more projects. The additional innovation and best practice sharing from the WHR programme and other projects (such as those outlined in the background section) could be applied to future projects, improving their viability.</p> <p>Whilst we do not anticipate that this project will on its own create a sustainable WHR market and supply chain, there are feedback loops within the ToC. For example, there is a feedback loop from PG11 to PG7 (as WHR demonstrates viability → market confidence increases → more projects delivered → which leads to more cost reduction (PG7) → increased viability)</p> <p>PG11 contributes directly over time to PG12.</p> <p>Key techniques, materials and business processes are integrated into commercial practice in retrofitting.</p>	<p>Depends on PG10 and previous steps being achieved successfully.</p>
<p>PG 12</p> <p>Increased WHR supply chain robustness</p>	<p>Increased supply chain capability and capacities because of the increased scale of WHR activity and the development of new and improved techniques, improved materials, and business practices</p>	<p>The government and/or industry takes forward techniques and business processes into retrofit activity.</p>
<p>PG13</p> <p>Increased likelihood of meeting Clean Growth Strategy and Buildings</p>	<p>In May 2018, government laid out the Buildings Mission, the first mission of the Clean Growth Grand Challenge, to at least halve energy use in new buildings by 2030 and drive down the cost of retrofitting an existing building to modern energy standards.</p>	<p>Assumes this and other projects demonstrate viability – achievement of this outcome is a consequence of all other steps and stages in the ToC.</p>

Mission targets	This project forms a key early step in delivering this aim, and by providing evidence about innovations that bring down costs, may help make retrofitting more attractive for owner occupiers funding their own measures.	
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Project level Theory of Change

In contrast to the programme level ToC, the project level ToC (see Figure 2) shows how the projects themselves will work with key stakeholders in introducing a range of innovations through implementation of WHR projects at scale in the context of social housing, and how these are expected to generate cost savings and contribute to other project level outcomes

Figure 2 The project level ToC (PJs¹⁷ are references to more detailed explanations below)

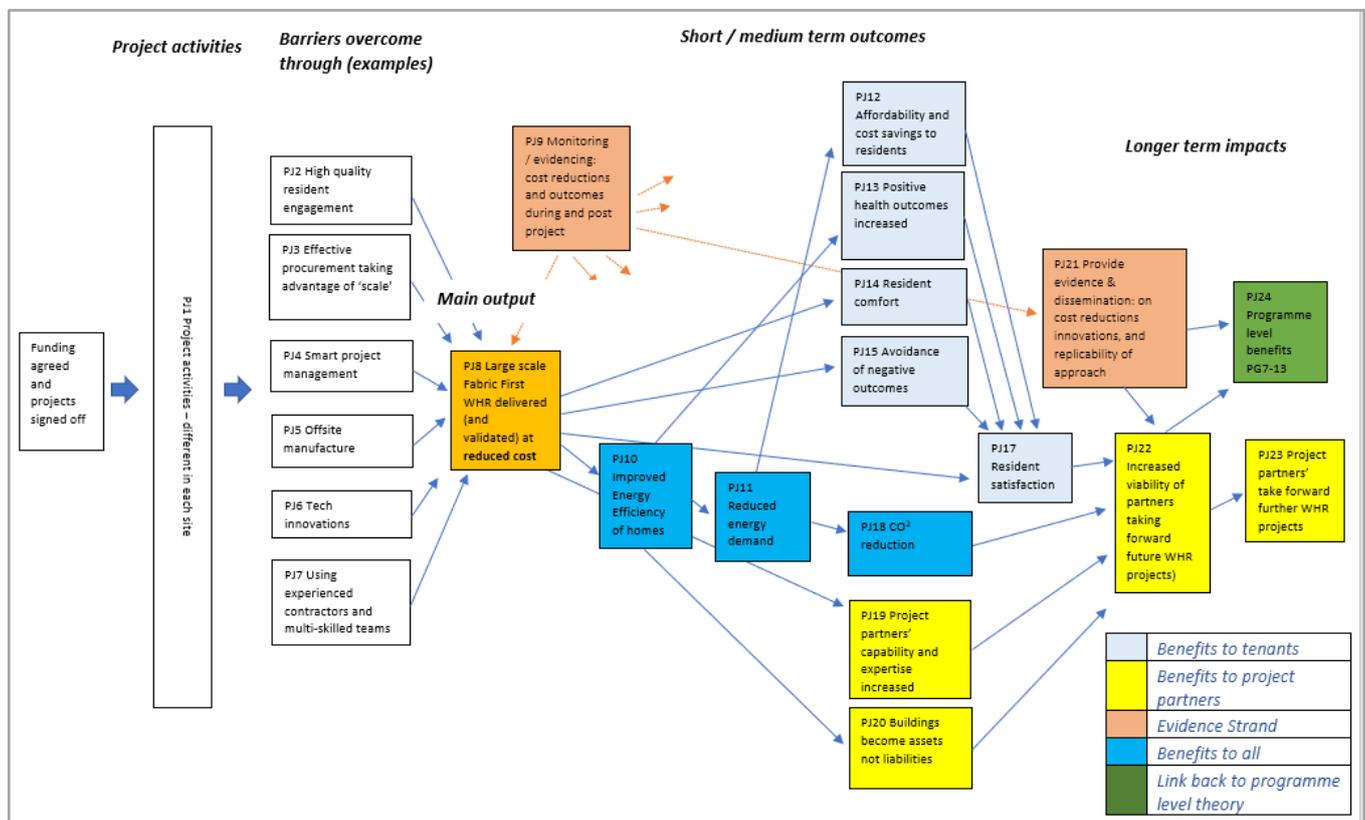


Table 2 describes each of these components in more detail.

Table 2- Further details on the project level ToC

Component	Further details	Assumptions
PJ1 Project activities –	Project delivery activities will vary project by project and are likely to include, for example:	All projects are awarded and go ahead.

¹⁷ PJ denotes project level, helping differentiate from components of the programme level ToC

<p>different in each site</p>	<ul style="list-style-type: none"> • setting up the project team and systems • setting up supply chain • identifying suitable properties and locations / communities, • undertaking initial property assessments • using ‘virtual models’ to estimate the impacts of different solutions. • Setting up and running QA systems <p>We do not propose to outline and build all these activities and outputs into project level theories of change¹⁸.</p>	
<p>PJ2 High quality resident engagement</p>	<p>Projects are using a range of techniques such as:</p> <ul style="list-style-type: none"> • Focus groups with dwelling representatives to assess impact and disruption and design and suggest mitigation strategies • Online platforms to communicate key milestones and important information with regards to the proposed works • Open days in some of the retrofitted homes to educate and train occupants on the new indoor environment (i.e. heating, cooling and ventilation). • Projects must undertake individual property assessments to determine appropriate measures, to inform residents about delivery arrangements that might affect households (e.g. access, health and safety), and to share details of likely property performance and post-installation monitoring. 	<p>High quality resident engagement depends on having clear objectives for resident engagement, great ideas for how to engage residents and strong resident engagement capabilities within the team. A variety of methods is assumed to be needed</p> <p>Partnerships which include a local council or social landlord will already have relationships with local residents. This should facilitate community engagement and help improve the recruitment rate (thereby helping avoid delays).</p>

¹⁸ It is not necessary to lay all these different activities onto this theory of change. Whilst these activities are all necessary for the delivery of the project we propose that the evaluation (and hence the causal mapping) focuses on an examination of the *innovations* used to reduce costs (the focus of the evaluation anyway) and their relationship with outcomes rather than the implementation of a wide range of relatively standard project activities which can be examined in the evaluation in a lighter-touch way.

	<p>Effective resident engagement throughout the project is likely to reduce the risks of low uptake and complaints, helping ensure a timely start to retrofitting works, especially as retrofitting requires residents to move out of properties for a period of time. Avoiding such issues through resident engagement can be expected to help bring project costs down by ensuring the project runs to time.</p> <p>Undertaking thorough and effective resident engagement requires careful planning – it requires for example, clear objectives, a good relationship with residents, and strong resident engagement capabilities. .</p>	
<p>PJ3 Effective procurement taking advantage of scale</p>	<p>Projects recognise the importance of the procurement stage – appointing competent and experienced contractors can help optimise the project’s VFM. Given the similarity in housing stock within each project, some projects are using vacant properties to show suppliers the retrofitting that is required, as well as providing a way of demonstrating how to achieve these retrofitting effectively. Such demonstrators help give contractors a better sense of the skills needed, and the techniques they could use to deliver the larger scale WHR at reduced costs. It will also help enable and early identification and mitigation of possible project risks.</p> <p>As the projects are commissioning at scale, they are in a stronger position to demand negotiation of materials at preferential rates, and a tighter management of the supply / supplier chain. Commissioning at scale also offers opportunities for multiple suppliers to work more effectively together as a team for example sharing resources (e.g. scaffolding) and building effective working arrangements. It may also provide opportunities for suppliers to innovate within their own processes and supply chain</p>	<p>Assumes high quality commissioning skills and sufficient supply chain capacity and capability.</p>

<p>PJ4 Smart project management</p>	<p>Projects can reduce costs through project design and smart project management and digital project management / workflow solutions. These may help mitigate delays and unnecessary costs arising as a result of, for example: labour waiting for materials to arrive, or materials such as scaffolding being on site waiting for labour to arrive, or contingent processes to be completed.</p>	<p>Assumes effective operations of smart project management techniques and good communication across a responsive network of suppliers.</p> <p>Assumes the work progresses without any difficulties with related steps (PJ2-3 and 5-7) as well as no external factors (see PG3)</p>
<p>PJ5 Offsite manufacturing</p>	<p>Off-site manufacture of retrofit components will drive efficiencies from logistics and reduce the amount of time spent on site. In some sites, for example, contractors make images of properties which they use to make modular components for later assembly on site. In another site, there is offsite production of roofs, helping reduce the time and costs associated with spending time on site.</p>	<p>Assumes applicability of off-site manufacturing to various components</p>
<p>PJ6 Use of technology innovations and system integration</p>	<p>There are likely to be technical and systems integration innovations that could reduce costs – for example, one project is using robots to provide under-floor insulation, which is cheaper and less complex than traditional methods.</p>	<p>Assumes effectiveness of technology and supplier skills</p>
<p>PJ7 Experienced contractors and multi-skilled teams</p>	<p>With the large volume of work they are commissioning, projects are able to make use of highly experienced national firms, with multi-skilled teams to deliver the work. As these teams gain familiarity and experience with whole house retrofit projects, there is scope to generate further efficiencies.</p>	<p>Assumes those that have not yet commissioned suppliers manage to secure the skilled contractors they seek in the WHR sphere.</p>
<p>PJ8 Large scale FF WHR delivered (and validated) at reduced cost</p>	<p>Further details outlined in Table 1 above, and in particular PG3</p>	
<p>PJ9 Monitoring / evidencing: cost reductions and outcomes</p>	<p>Further details outlined in Table 1 above and in particular PG4, 5 and 6</p>	

<p>PJ10 Improved home energy efficiency</p>	<p>Successful installation of WHR measures is likely to lead to significant improvement in buildings' airtightness and ability to retain heat. Numerous tests can verify this, including pre-and-post-retrofit airtightness tests, thermographic surveys, logging of environmental conditions, and the use of heat loss coefficients, u-values and surface temperatures of thermal elements. Some projects expect to obtain post-completion assessments for EPC certificates to verify improvements in EPC ratings. Projects are expected to achieve a 30kWh / m²/ yr performance.</p> <p>Each project is proposing its own methodologies and tests but details in project applications are very limited (see Annex 3 – Project's plans for technical performance assessment).</p>	<p>Assumes that any differences between the designed and measured energy efficiencies are addressed. BEIS requires that projects use a robust approach to post occupancy evaluation (POE) to ensure performance.</p> <p>Risks: Studies addressing the post occupancy evaluation (POE) of retrofits have often found significant performance gaps between the designed and the measured energy demand in dwellings, before and after the retrofit works. To mitigate this, BEIS requires projects to propose a robust methodology in ensuring the designed energy demand reductions have been achieved in practice.</p>
<p>PJ11 Reduced energy demand</p>	<p>Energy efficiency improvements in the home should typically result in reduced energy demand. Local projects have proposed approaches to measuring changes in energy demand. This is likely come through a pre and post retrofit energy demand assessments and modelling.</p> <p>There may be challenges in robustly assessing the impact of the retrofit on 'in-use' energy demand using pre-post smart meter data or bills due to a) seasonal weather variation and b) human factors (e.g. people may use more heating after retrofit due to the reduced costs of heating their homes).</p>	<p>Assumes energy efficiencies (PJ10) are achieved.</p> <p>Assumes occupants / residents behave rationally and logically</p>
<p>PJ12 Affordability and cost savings to residents</p>	<p>With increased energy efficiency and reduced energy demand, the cost of heating homes should fall, and in turn, reduce the number of residents deemed to be fuel poor. A £/kWh/m²/yr heat reduction statistic offers one way of assessing cost reduction.</p>	<p>Assumes PJ10 and PJ11 are achieved.</p>
<p>PJ13 positive health</p>	<p>Cold homes are associated with a wide range of poor health outcomes and an</p>	<p>Achieving these health outcomes, assumes that</p>

<p>outcomes for residents</p>	<p>increased risk of morbidity and mortality for all age groups¹⁹.</p> <p>According to MOs many homes in the project areas have reported instances of cold spots, damp and mould growth resulting from poor energy efficiency, and lack of heating use due to fuel poverty.</p> <p>WHR measures should help residents to heat their homes to comfortable levels, and to avoid negative health outcomes damp, and mould growth, thereby reducing risks to residents' health.</p> <p>BEIS requires measurement of resident health outcomes and projects have outlined their initial plans for this in project applications (see Annex 2 Collection of data on resident outcomes).</p>	<p>people behave rationally – using their heating and home in ways anticipated by engineers and WHR designers.</p> <p>It also assumes that projects manage to avoid unintended negative consequences of retrofit (such as those listed in PJ15) to prevent condensation, mould and damp).</p>
<p>PJ14 Resident comfort</p>	<p>As noted above, residents need to be able to heat homes to a comfortable level.</p> <p>Resident surveys and interviews are expected to provide relevant data.</p>	
<p>PJ 15 Avoidance of negative outcomes</p>	<p>Projects need to prevent post-retrofit over-heating (in summer for example), condensation, mould growth and damp. This can result from thermal bridges and a lack of ventilation. If these occurred, they might also generate negative health outcomes for residents.</p> <p>Other installation faults may additionally present risks of negative outcomes.</p> <p>These risks will require pre-emptive mitigation strategies, as well as ongoing monitoring and management.</p> <p>BEIS has stipulated that projects must demonstrate an approach to dwelling-level quality assurance of all installations during works, on completion and post-installation.</p> <p>BEIS requires projects to use technical measures pre-and post-retrofit, plus resident surveys and consultation to assess</p>	<p>Assumes POE measures and QA processes will be in place to ensure that any issues arising are put right.</p>

¹⁹ Public Health England / UCL Institute of Health Equity, Health Equity Evidence Review 7 (September 2014): Local action on health inequalities: Fuel poverty and cold home-related health problems,

	outcomes and effectiveness of mitigation strategies.	
PJ16 Resident satisfaction	<p>This could entail satisfaction both following the completion of WHR measures, and comfort and satisfaction during the WHR process.</p> <p>Satisfaction following the completion of WHR measures is likely to be influenced by comfort (PJ14), avoidance of negative outcomes (PJ15), health benefits (PJ13) heating cost reductions (PJ12). It is also likely to be influenced by aesthetics and the quality of post-installation monitoring and customer care and defects resolution. .</p> <p>Resident satisfaction during and / or resulting from the retrofit process might be linked to the sense of disruption experienced, as well as the actual experience of moving out during the retrofit. The length of time of the retrofit, the quality of alternative accommodation and the quality of information provided during the retrofit may also influence satisfaction.</p> <p>We understand that projects plan to look at satisfaction through resident surveys and consultation methods.</p>	Assumes that the programme's clear focus on cost reduction and energy efficiency does not result in projects missing out on other opportunities to enhance resident 'satisfaction .
PJ18 CO2e reduction	Reduced energy demand will lead to a reduction in CO2 emissions.	Assumes PJ10, 11 are achieved
PJ19 Project partners' capability and expertise increased	<p>The project will give partners considerable opportunities to learn and build capabilities– both in terms of implementing innovations needed for cost reduction, but also those needed for effective WHR across a partnership.</p> <p>Regular learning capture, final report, and project evaluations should capture learning around capabilities and skills.</p>	Assumes learning and evidence is integrated into business knowledge management, learning and skills development systems
PJ 20 Buildings become assets not liabilities	Poor build quality and energy efficiency of existing stock has led to deterioration in the condition (and value) of some council-owned assets. Investing in building shells and achieving energy efficiency of housing stock means that councils will see their	Assumes projects are successful.

	stock as financial assets rather than a liability.	
<p>PJ 21</p> <p>Provide evidence & dissemination: on cost reductions innovations, and replicability of approach</p>	<p>The projects need to deliver periodic update reports and a final report (which BEIS says must be publishable), describing all outputs and applicable lessons learned.</p> <p>Section 5.3 outlines the detail of these reports.</p> <p>Dissemination of findings is also key to achieving wider programme benefits PJ22 (further local projects) and PG10 – encouraging other (national) stakeholders to consider WHR projects. Projects have proposed extensive dissemination plans:</p> <ul style="list-style-type: none"> • Live web pages, blogs on project progress, newsletters • Offering site visits throughout the project (targeting other housing organisations, policymakers, main contractors/solution providers, component manufacturers, and investors) • Academic papers on behaviour change, and resident experience and outcomes • Awards submissions • Delivering a conference • Contributing to existing industry events and conferences • Establishment of networks 	<p>Assumes projects are successful and that projects are successful in collecting robust and validated data, and that they are able to disseminate findings effectively</p>
<p>PJ22</p> <p>Increased viability of future WHR projects</p>	<p>By achieving and evidencing WHR at reduced costs, and building capability and expertise, the BEIS-funded projects should be better placed to develop plans and seek funding for further deployment. This may include similar projects, but additionally may extend into other housing archetypes, tenures and sectors</p>	<p>Assumes successful project, learning and expertise captured.</p>
<p>PJ23</p> <p>Project partners' take</p>	<p>Project partners take forward further WHR projects resulting from the success of this project</p>	<p>Assumes viable funding or business opportunities.</p>

forward further WHR projects		
PJ24 Programme level benefits (short and longer term)	The benefits at the project level collectively feed into the benefits chain illustrated at the national level (see PG 7-13 in the programme level ToC)	Assumes overall success.

Summary of Expected Benefits / Outcomes

Both the programme and project level ToCs refer to a number of different outcomes. Table 3 summarises these, as well as highlighting the likely timescales over which these might be observable, and therefore potentially measurable. .

Table 3: Summary of anticipated benefits

Time frame for outcomes	Project outcomes (taking place in project sites)	Programme outcomes (taking place nationally, over and above aggregation of project benefits)
Outcomes that could start to be measured in the short term ²⁰ (by approximately October 2021) These can mostly be measured at household level	<ul style="list-style-type: none"> • Improved energy efficiency of homes • Reduced energy demand • Reduced CO2e emissions • Resident comfort, reduced heating costs, • Resident satisfaction increased • Reduced risk of fuel poverty • positive health outcomes Negative outcomes avoided (e.g. overheating in summer, condensation, damp due to thermal bridges and lack of ventilation) 	<ul style="list-style-type: none"> • Cost of WHR demonstrably reduced • Evidence and learning about how to reduce costs available to government and others • Able to demonstrate cost / benefits of WHR to HM Treasury and to the EE sector.
Outcomes - that will need to be	<ul style="list-style-type: none"> • Project partners' capability and expertise increased 	<ul style="list-style-type: none"> • National capabilities and expertise increased

²⁰ Referred to as 'Short term' outcomes, but benefits of these short term outcomes can be expected to accrue in the medium and longer term

<p>measured in medium / longer term from October 2021 – 2025 and beyond).</p> <p>These are measured at a range of levels in the medium and longer term</p>	<ul style="list-style-type: none"> • Buildings become assets, rather than liabilities • Interest in WHR may be increased amongst owner occupiers in domestic and non-domestic sectors • Increased viability of future WHR projects – in similar and possibly amongst other housing archetypes, tenures and sectors 	<ul style="list-style-type: none"> • Interest and confidence grows amongst potential funders of WHR (e.g. HM Treasury, social housing, owner occupiers in both domestic and non-domestic settings) • More projects taken forward with and outside of BEIS programming • More projects innovate to bring costs down • Costs of WHR continue to fall
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4. Evaluation purposes and questions

Purposes and uses of the evaluation

The programme aims to reduce costs of WHR and generate evidence and learning on how to reduce these costs. The programme's evaluation will examine the evidence of cost reductions and trace the different innovations that are expected to reduce WHR costs. Projects and the evaluation alike are expected to generate evidence on how and where future cost reductions might be found.

The evidence generated is expected to inform future policy and spending decisions. The learning will help inform the design, delivery, and budgeting of comparable projects, ultimately helping the government to more meet targets of halving WHR costs **and** halving energy use in new buildings by 2030.

BEIS will be one of several stakeholders with interest in the evaluation's findings. For instance, there is likely to be local-level interest in the lessons learned with a view to supporting effective design and implementation of future local WHR projects.

Levels of evaluation

Stakeholder feedback revealed interest in both programme and project level evaluations, the latter helping assess four different approaches to undertaking WHR at scale, all covering different approaches and contexts. Project level evaluations will build on project-specific monitoring and evaluation activity already being planned by projects (as outlined further in Section 5).

The programme level evaluation can to some extent draw on an aggregation and synthesis of project level findings, but the 'programme level perspective' will also require additional data collection and analyses. In addition, there are supplementary questions to consider at this level, including the operation of the competition process, and evaluating programme level benefits.

Programme level evaluation

The programme level evaluation should primarily examine the key elements of the programme ToC. The evaluation will focus on:

- the effectiveness of the grant competition
- the effectiveness of projects in achieving WHR at reduced costs
- the learning from the design and delivery of the projects
- the short, medium- and longer-term benefits of the programme (the latter for example including the spread and scaling of WHR either via government funded projects or commercial adoption)
- the overall VFM provided by the programme.

Project level evaluation

The project level evaluation(s) are needed to evidence how different projects have overcome the main barriers and obstacles to delivering WHR with cost reductions. The evaluations will need to:

- validate, and trace the sources of, cost reductions
- examine delivery and implementation of each project
- validate evidence about, and generate explanatory accounts of, project outcomes (including unintended outcomes) outlined in the theories of change

Table 4 below sets out the key evaluation questions most relevant to the programme and project level evaluations. It also sets out the key sub-questions at the programme and project levels, reflecting the different analytical perspective applicable at the two levels. We also set out the project and programme level ToC components that each high level evaluation question refers to, plus the likely relative level of evaluator effort that will be required, having considered the practicalities (e.g. likely availability of existing data, and the challenges in collecting new data).

Table 4 Proposed WHR evaluation questions

High Level question	ToC reference	Level of evaluator effort required	Project level sub-questions	Programme level sub-questions
1 How effective were the BEIS grant competition and the technical support provided to projects during the programme?	PG1	Low	<ul style="list-style-type: none"> • How did the competition influence the design of the project? • How do project leads believe the competition design could be improved? • How helpful have project leads found the support provided to them over the projects' duration? 	<ul style="list-style-type: none"> • Did the competition secure sufficient viable bids from organisations most capable of delivering the ambitions of the programme? If not, why not? • Did the technical support provided to projects contribute to their effectiveness?
2 What is the learning about projects' design, development, and delivery?	PJ1	High	<ul style="list-style-type: none"> • Which elements of the project's technical approach to WHR went well and which less well? • What impact did key elements²¹ of the project have on successful project implementation? • What learning is there about required skills and organisational relationships 	<ul style="list-style-type: none"> • How viable are different (technical) approaches to WHR in different circumstances? • What is the wider learning from across the projects about running a large scale WHR project?

²¹ Such as resident engagement, quality assurance and mitigation strategies, technical measurements, and hand over arrangements

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			needed to deliver large scale WHR?	
3 How effective were the projects in achieving WHR at lower than normal costs?	PG2 -6 & PJ 2-7	High	<ul style="list-style-type: none"> • What was the difference between anticipated and actual costs? • To what extent were project innovations delivered? • What impact did each of the process innovations have on costs? • What other factors influenced project costs – positively / negatively? 	<ul style="list-style-type: none"> • What explains any differences in cost reductions achieved across the projects? • What are the main sources of cost reductions across the sites? • How do cost reductions compare with those found in other programmes?
4 What are the short-term outcomes? (see Table 3 above)	PJ 10-18	Moderate	<ul style="list-style-type: none"> • What were the project's technical performance and resident outcomes? • How were these outcomes generated? 	<ul style="list-style-type: none"> • How do (short term) project-level outcomes vary across projects? • What explains this variation? • What is the contribution of the programme to these outcomes?
5 What are the (potential) medium- and longer-term outcomes? (see Table 3)	PJ19-24 and PG 7-13	High	<ul style="list-style-type: none"> • What are the medium- and longer- term impacts at the project level (actual if possible, anticipated if not)? 	<ul style="list-style-type: none"> • What explains any differences in estimated / actual medium- and

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			<ul style="list-style-type: none"> • What explains these outcomes? 	<p>longer-term outcomes for projects?</p> <ul style="list-style-type: none"> • To what extent are the methods and approaches likely to be applicable to similar WHR activity elsewhere in similar or different contexts; and with similar or different tenures and housing archetypes? • What are the national / programme level outcomes? • What is the combined contribution of the projects to national outcomes?
6 Does the investment represent good value for money?	All benefits specified in the ToC (and inputs not included in ToC (see VFM section later in report)	Low	<ul style="list-style-type: none"> • What input, output, outcome and behavioural additionality can be attributed to BEIS funding? 	<ul style="list-style-type: none"> • What did the BEIS funding achieve? • Does the net present value of benefits outweigh the programme costs?

5. Research methods and data collection

In this section we set out the research methods and data needed to answer the evaluation questions set out above.

Existing data sources

There is already a wide variety of pre-existing data and information that the evaluation will be able to draw on. Documents such as the programme business cases, competition guidance, competition Q&A, and project applications will all be important information sources.

Projects themselves will need to produce two reports: a final installation report by March 2021, and a final monitoring report by September 2021. We also understand that as part of their grant agreement, projects will have to collect and analyse a wide range of their own data which we have assumed will be made available to evaluators – projects have outlined their plans for this which we summarise in Table 5.

These reports, plus the underlying data underpinning them will be key information sources for addressing the evaluation questions. However, there is no stipulated methodology for monitoring resident participation and engagement, technical performance of measures, evidencing cost reductions, measuring resident outcomes and evidencing replicability of the approach – BEIS has given each project freedom to design its own approach.

Table 5 sets out our understanding of the kinds of data that should be available to evaluators – based largely on BEIS guidance but also brief information provided in project applications. We understand that projects will also bespoke monitoring and evaluation plans at a later stage, the initial focus having been on project initiation.

Table 5 Existing or planned project level data sources

Data Source	Further Details	Relevant evaluation question	Timing
Projects' final reports	<p>Projects must produce periodic reports, and a final publishable report. These must provide detailed information on:</p> <ol style="list-style-type: none"> 1. Technical performance and energy demand reduction. A list of all the measures installed and the expected performance of the dwellings. Data also needed on energy demand reduction performance and results of other post retrofit in-situ measurements. 2. Management of the performance gap. Steps taken to mitigate potential risks in sustaining the improved energy performance of the retrofitted stock; any training or guidance material used, material provided as part of the handover of the upgraded fabric envelope and systems. Reasons for any deviations from targets set and associated actions taken. 3. Cost reductions. Evidence on the drivers and sources of cost reduction from scaling whole house retrofit (e.g. processes, design, methods, materials, technologies, supply chain, working practises, labour) 4. Lessons learned during the retrofit works. Documentation of challenges, barriers and any learning. 5. A road map for delivering whole house retrofit to mass deployment, including the achievement of a 50% reduction in costs of retrofitting a whole house by 2030. This should provide evidence on the replicability and scalability of the approach based on the economic, technical, political and social barriers identified during the project. 	All	Periodic Final reporting (March 2021 & September 2021)

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Projects' monitoring of resident take-up of the WHR offer	Although not mandated in the guidance, projects are likely to have plans to collect data about resident take up of the WHR offer and drop out.	Q2	Ongoing
Projects' evaluative data collection with residents	Projects must collect qualitative data on the health, comfort and well-being of occupants before and after project completion, using (for example) in-depth interviews and surveys with household members. We recommend that the evaluators work with the projects to help design the surveys, providing guidance on appropriate questions to ask, survey design, and strategies for maximising response rates and to maximise consistency of project surveys to facilitate programme level evaluation. The projects themselves should retain responsibility for issuing the survey and securing responses.	Q4	Ongoing (before and after installations)
Projects' quality assurance	According to BEIS competition guidance, projects must implement robust QA procedures for all installations <i>“to ensure that the risk of unintended consequences from whole house retrofit (including overheating and damp/mould) on a dwelling by dwelling basis can be identified and mitigated on every step of the retrofit process, from early stage design to after the completion of the works, through the use of technology as well as training and education (e.g. thermography, moisture sensors, air tightness measurements, personnel training, CPD, etc.)”</i>	Q2 & 4	Ongoing
Projects' technical performance assessments	<p>Projects must measure technical performance of the installations and refits. BEIS priorities are:</p> <ul style="list-style-type: none"> • Thermal efficiency • Energy demand and CO2 emissions • Performance Gap <p>Suggested measures include:</p> <ul style="list-style-type: none"> • Internal air temperatures • Humidity 	Q4	Ongoing (before and after installations)

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	<ul style="list-style-type: none"> • Air tightness • Thermographic surveys • Logging environmental conditions • Occupant surveys • Logging actual energy consumption and co-heating tests • Internal temperatures • Heat loss coefficients • U-values and surface temperatures of thermal elements • Air quality metrics (VOCs, Co2, Particulates) <p>Information on this is set out in Annex 3 – Project’s plans for technical performance assessment.</p>		
<p>Projects’ cost reduction methodology</p>	<p>Projects must also develop their own approach to calculating cost reductions of WHR. As stated in the competition guidance: <i>“The reduction of cost is the most significant part of this project, therefore concrete evidence of achieving the required outputs must be brought forward in a clear and concise manner. Evidence of cost reduction should be based on records of individual energy efficiency measures as well as previously completed whole house retrofit projects that are of similar characteristics to the proposed dwellings.”</i></p> <p>We have not seen the specific cost reduction calculation methodologies that each project has proposed but again, believe this will be a useful starting point for the evaluation. However, the ability to test causal relations between theorised process innovations and costs / cost reductions will depend on comprehensive monitoring of both within each project.</p>	<p>Q3</p>	
<p>Project costs data</p>	<p>Projects will keep records of all costs incurred during the project – which we understand will be available to the evaluator</p>	<p>Q6</p>	

Better understanding each project's monitoring and evaluation plans

As noted earlier, the above table is based on limited project level information that was available to support the scoping phase. We have assumed that the data set out in Table 5 will provide a useful starting point for the evaluation but it was not within scope of this project to determine the robustness and suitability of these plans or to understand where the gaps might be.

It will therefore be important during the evaluation's initial phase to review each project's plans for monitoring, outcome measurement and wider evaluation activities and make any recommendations to improve each project's approach, and consistency across projects.

The evaluators should review projects' plans for data collection on the following:

- **levels of WHR take-up** amongst residents
- **impacts on residents' health, comfort, and well-being**²² pre- and post-occupancy. Projects are planning various forms of data collection such as surveys and interviews.
- **technical performance measurement**²³. Some information has been provided in projects applications but full details could be made available to the future evaluator.
- **cost reductions**. Currently, there is limited information on how projects plan to track cost reductions and the likely sources of these.
- **estimating likely scale up / replication**. This is a requirement of BEIS funding but again, there is currently limited information on how projects plan to monitor this, which will be an area for the future evaluator to explore as part of the project scoping stage.

In particular evaluators should consider:

- the coverage of topics and whether there are any data or content gaps
- sampling arrangements
- data collection both pre-and post-installation
- the approach to estimating the counterfactual
- suitability of timeframes for outcome assessments

²² Experimental or quasi-experimental designs are unlikely to be capable of measuring the 'in use' impact of installations on resident outcomes and performance because of the difficulties in finding and collecting data from suitable comparator households to those that have received WHR support. We recommend further consideration of the possible approaches for this – recognising that whilst not the focus of the evaluation it is an important aspect for VfM assessment in particular.

²³ Ibid.

Proposals for new data collection

Interviews

While planned or existing data will certainly be helpful, the evaluation will need to capture additional primary data to answer the evaluation questions. These will largely come through a series of semi-structured interviews with groups highlighted in Table 6. In many cases, the evaluators may want to speak with interviewee groups twice, initially after project delivery completion (March 2021) to address high level questions 1-3 and then again shortly after organisations are expected to have completed and reported on planned post-occupancy outcome monitoring (September 2021).

For some key groups, we recommend an additional interview (or workshop) shortly after project inception (Q4 2020) to help create individual project theories of change, to obtain a clear picture of how and when projects will be delivered, and to understand what firm plans the projects have for monitoring and data collection.

Table 6 Suggested additional interviews

Interview group	Further details	Evaluation questions covered	Frequency and timing of interviews
BEIS staff (x5)	BEIS programme managers and members of SICE	Q1	Once – shortly after evaluation inception
Monitoring Officers (x4)	Three monitoring officers who are responsible for the four projects, plus their manager.	All	Three times – shortly after evaluation inception; March 2021, and September 2021
Project leads (x4)	With one or more representatives of the lead organisation for the consortium of organisations delivering funded projects	All	Three times – shortly after evaluation inception; March 2021, and September 2021
Social housing landlords for each consortium (x4)	Landlords include local authorities and housing associations	Q2	Twice - March 2021 and September 2021
Key project partners for each consortium (x10)	2-3 partners and suppliers ²⁴ in each project, appointed by consortium	Q2	Twice - March 2021 and September 2021

²⁴ May include for example: consultancies (architects, analysts, research and communications), retrofit materials suppliers, retrofit installers, building / construction companies, energy firms, comms firm

Optional resident interviews (x40)	15 minute interviews with ten residents in each project (where deemed necessary)	Q3, Q4, Q5	Once – September 2021
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We envisage the evaluators conducting semi-structured interviews, using a topic guide rooted in the evaluation questions and relevant sub-questions. Where possible, the interviews with BEIS programme staff, Monitoring Officers and Project Leads should be face-to-face (or by video call if restrictions to movement remain when the evaluation is commissioned). Either of these media should enable the sharing and discussion of materials such as theories of change, and data tools. All other interviews can take place via telephone.

We also advocate receiving feedback from residents to better understand the level and nature of outcomes seen in terms of comfort and health, whether the retrofitting has led to any behaviour changes in energy usage, and to help determine the suitability of different WHR approaches to different dwelling types. This will help provide some perspectives on scalability. Such evidence will come in large part from the projects' own residents and as noted above, we have already recommended that the evaluators work with the respective projects to design. As an additional optional task, we suggest carrying out in-depth qualitative telephone interviews with up to ten residents in each project. These additional interviews will only be necessary for those projects where the evaluators do not feel that existing project-level data collection methods provide sufficient resident feedback. Where additional interviews occur, they could focus as necessary on the effectiveness of programme delivery processes, and potentially help highlight whether household types affect the receptiveness to different WHR approaches. The projects' own surveys could include a question where residents can opt in to a future interview and provide contact details, helping tackle any potential data protection issues.

Wider evidence review and consultation with other WHR projects

It would be helpful comparing the BEIS WHR programme with other ongoing or completed WHR projects such as Innovate UK's Retrofit for the Future²⁵, the Mayor of London's Energy Leap²⁶, London's Retrofit Accelerator²⁷, Accelerator Cities Pathfinder²⁸ and Nottingham's deep retrofit project.²⁹

Reviewing evidence and insights from these programmes could be undertaken both during the evaluation's inception phase, and towards the end of the study. A review at inception will help further develop the programme and project ToCs by enabling a more nuanced and refined understanding of the causal relationships and the assumptions underpinning them. A second review towards the end of the study will help contextualise the findings of the WHR project, enable an assessment of relative performance, and help to validate estimates of future cost trajectories.

Any comparator project reviews should examine:

- planned and actual WHR solutions

²⁵ <https://retrofit.innovateuk.org/>

²⁶ <https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/energy-leap-project-pilots>

²⁷ <https://www.london.gov.uk/what-we-do/environment/energy/retrofit-accelerator-homes>

²⁸ <https://www.ukgbc.org/ukgbc-work/accelerator-cities-pathfinder/>

²⁹ <https://www.energiesprong.org/projects/nottingham>

- actual costs of WHR in these projects
- planned and actual innovations and any sources of cost reductions
- outcomes achieved in these WHR projects, and factors influencing project outcomes
- potential for scaling up innovations from these projects
- validating findings about medium and longer-term programme outcomes – for example examining evidence which would help determine the relative contribution of these programmes and the BEIS WHR programme to national WHR cost reductions
- technical support and funding mechanisms underpinning these projects

The starting point should be a review of existing publications and any available secondary data. However, it may also be appropriate to build on these reviews via interviews with project managers at these comparator schemes. The interviews will also provide an opportunity for comparator project leads to provide more direct views on the BEIS-funded WHR scheme.

It will also be helpful to monitor the development of any new WHR programmes that emerge during the course of the evaluation. If additional programmes do arise, then research interviews with them may help understand the potential role and impact of the BEIS project on the design, costs, strategies and likely outcomes of these new schemes.

Existing and project datasets

The evaluation should also use existing national datasets about the UK housing stock to help validate any project-level estimates on the scalability of findings. We recommend this taking place after project completion in March 2021, and then updated following programme completion.

6. Evaluation methodology

This section discusses the types of evaluation methods that we consider to be in scope for an evaluation of the WHR competition. We discuss the key design features of each method, and which phase of the evaluation each one may be appropriate for. We then provide recommendations on a core set of evaluation methods, and strands of data collection and analysis.

Proposed approach

As indicated by the list of evaluation questions, the WHR evaluation needs to include **process evaluation** elements (what can be learned from how the intervention was delivered), **impact evaluation** elements (what difference has an intervention made, to whom and how), and **value for money evaluation** elements (is the intervention a good use of resources). Understanding all three of these will be crucial to determining the potential of scaling up WHR approaches to other sites.

The process evaluation centres on examining how effectively and efficiently the projects' and programme delivered WHR. This is best explored through analysis of existing documentation and qualitative research, underpinned by a clear framework defining key processes and how these may contribute to programme success. The value for money evaluation will weigh up the (societal and economic) costs and benefits of both the programme and the projects using a combination of monetary values developed by the projects themselves, BEIS and benchmark figures derived from secondary data analysis.

The impact evaluation will deal with assessing what difference the programme made, and how and why the outcomes and impact(s) occurred. As highlighted in the 2020 *Magenta Book*, there are two fundamental evaluation designs that evaluators should use:

- **Theory-based evaluations** – these work by setting out an explicit programme theory (how the programme is expected to work) which provides a basis for investigating both implementation processes and causal relations of interest³⁰. As the evaluation progresses, key relationships, explanations and assumptions within the 'theory' are better understood, allowing a refinement of the theory to better reflect reality and causal relationships. They are most appropriate for assessing how and why outcomes and impacts occurred.
- **Experimental and quasi-experimental evaluations** – these use a counterfactual group whose outcomes can be compared to that of the intervention or treatment group. Experimental evaluations use a form of randomisation in developing a counterfactual group, often through the use of a randomised control trial.³¹ Quasi-experimental methods also use a counterfactual but without randomisation. These methods are most appropriate for quantifying the impact of a programme or project.

³⁰ <https://www.intrac.org/wpcms/wp-content/uploads/2017/01/Theory-based-evaluation.pdf>

³¹ Where a number of similar people are randomly assigned to two or more groups to test an intervention. One receives the full intervention while other groups either receive no or partial intervention.

We suggest that the evaluation predominantly utilises theory-based methods for impact evaluation but also, where possible quasi-experimental approaches (within projects at household level).

Impact evaluation methodology

We recommend a theory-based approach to examine how projects, and the programme overall achieves **the main output** (cost reductions), as well as, **medium- and longer-term outcomes**. A theory-based approach is particularly suited to of the evaluation of WHR where the focus is on verifying whether and determining how individually, and collectively, innovations have contributed to cost reductions. Theory-based approaches are also more appropriate for the tracing of effects that produce more medium and longer term outcomes (see Table 3) are also more feasible using theory based approaches.

Given the variety of contexts, models and approaches to cost reductions used in the WHR programme, we also recommend that the theory-based evaluation adopts a broadly 'realist' philosophical and analytical approach. Using a realist lens in evaluation means recognising that interventions have to operate differently in different contexts to achieve their desired outcomes. Realist evaluators are interested in how these different programmes have adapted to contexts, and particularly how interventions achieve outcomes in these different contexts.³²

We recommend two specific theory-based methods - contribution analysis and process tracing – which we will outline later in this section. These methods are entirely compatible with a 'realist framing' stemming from the same philosophical viewpoint with regard to ontological, and epistemological issues.

Using a theory based approach outlined below will also involve using multiple analyses at a programme and project level to determine not only why observed changes occurred (and what role BEIS funding may have played in these), but also help qualitatively assess the counterfactual – what would have happened (in terms of cost reductions, and medium and longer term effects) without the programme or BEIS funding.

We have already outlined and presented (see page 12) a case for taking a 'generative' approach to the analysis of causal relations rather than successionist ones. We do not believe a statistical or quasi-experimental design would help determine or demonstrate programme or project causal mechanisms, and their contribution to medium or longer term outcomes. There are also practical reasons - a quasi-experimental approach to counterfactual assessment is not feasible for the WHR programme as a whole due to the small population of projects supported as well as the small number of unsuccessful applicants.³³

However when it comes to measuring (short term) **project level outcomes** for households (see Table 3), we think a robust estimate of the counterfactual will be very important – as the main concern here is quantifying the average impact of installations on households. We understand that some projects plan to use technology and modelling to help quantify the impacts of WHR on households (energy efficiency of properties, energy demand, Co2e

³² <https://www.intrac.org/wpcms/wp-content/uploads/2017/01/Realist-evaluation.pdf>

³³ For instance, Regression Discontinuity Design (comparing outcomes for projects that were just above and just below the funding scores) is not feasible given the small number of WHR applications that BEIS received. Similarly, Difference in Difference analysis (comparing outcomes of applicants awarded funding with a sample of similar stakeholders not participating in the WHR competition) is not feasible as there are relatively few examples of the market delivering WHR at scale (as already highlighted in Section 2).

reductions, resident satisfaction and health). We recommend that the evaluator reviews these approaches to ensure that projects apply robust counterfactual approaches and as consistently as possible to enable an aggregation of findings.

Theory based analysis of the factors influencing net impacts (e.g. different WHR installations, different housing archetypes, different populations and contexts) will also be helpful in qualifying and explaining the different outcomes across projects. We do not think there is a case for pre-specifying how projects should measure impact. This would be a major burden on projects, and whilst a consistent assessment of household level impacts would help the VfM assessment, estimating the net impact of the programme on household level outcomes is not the evaluation’s main priority.

In the next section – we outline the methodology, linking key data to evaluative strategies and high-level questions. In the second part we outline in more detail some of the specific methods proposed.

Linking evaluation questions to data and evaluative and analytical techniques

The ‘nested’ approach to theory of change that we have outlined earlier in the report (in which the project ToC is a smaller subset of the programme ToC) is also reflected in our thinking about the approach to linking evaluation questions, evaluation methods, analysis and reporting.

Table 7 below sets out how different analytical and evaluative approaches (as per Section 3) and different data sources (as per Section 5) can be used together to address the proposed programme-level and project-level evaluation questions. In most cases, project level findings can help inform a programme level analysis and synthesis but it is not always the case that findings can simply be aggregated or synthesised. To enable the synthesis of project level findings, we recommend drafting separate analyses (be they individual case vignettes, report chapters, or whole reports) for each individual project. These reports should build on each project’s completion report, further supplementing them with revised project level theories of change, and using additional data collected and analysed by the evaluator. The analyses should address each of the key evaluation questions (Table 4), providing the basis for the programme level analysis and syntheses set out in Table 7.

Table 7 Linking questions to data to evaluation and analytical techniques

High Level Evaluation Question	Research / Data sources (see Table 5 for more detail)	Evaluative methods and analytic techniques	
		Project level	Programme level
1. How effective were the BEIS grant competition and the technical	<p>Analysis of programme documentation on the competition</p> <p>Interviews with BEIS staff, MOs and Project Leads about the competition process</p>	<p>Lessons learned:</p> <p>Analysis of programme documentation, and qualitative data analysis of the findings of</p>	

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support provided to projects during the programme?		interviews with BEIS and project staff	
2. What is the learning about projects' design, development, and delivery?	<p>Analysis of project level reports</p> <p>Analysis of raw data from monitoring resident take up</p> <p>Analysis of interviews with project leads, monitoring officers, social landlords, and other key project partners to understand key activities and processes, challenges and learning, skills-sets needed</p> <p>Wider evidence review / consultation with other WHR projects to examine how findings compare with other projects</p>	Systematic Qualitative Data Analysis	Comparative analysis and synthesis of project level findings
3. How effective were the projects in achieving WHR at lower than normal costs?	<p>Analysis of project level reports</p> <p>Analysis of raw data on cost reductions</p> <p>Analysis of findings of interviews with project leads, monitoring officers, and project partners</p> <p>Wider evidence review / consultation with other WHR projects to examine how findings compare with other projects</p>	<p>Systematic Qualitative Data Analysis</p> <p>Contribution analysis (with process tracing)</p> <p>Detailed refinement of project level ToC</p>	<p>Comparative (realist) analysis</p> <p>Aggregation and synthesis of project level findings</p> <p>Detailed refinement of programme level ToC</p>
4. What are the short-term outcomes?	<p>Analysis of project level reports</p> <p>Analysis of raw data on pre-post performance and resident experiences and outcomes</p> <p>Analysis of findings of interviews with project leads, monitoring officers, and project partners</p>	<p>Validation of project estimates / secondary analysis of project data</p> <p>Systematic qualitative data analysis</p> <p>Detailed refinement of project level ToC</p>	<p>Comparative analysis</p> <p>Aggregation and synthesis of project level findings</p>

<p>5. What are the (potential) medium and longer-term impacts?</p>	<p>Analysis of findings of interviews with monitoring officers and project leads to understand potential for scaling up locally, and nationally, and for further cost savings</p> <p>Review of any new project business cases / funding applications</p> <p>Wider evidence review / consultation with other WHR projects to examine how findings compare with other projects</p>	<p>Project level contribution analysis (with process tracing)</p> <p>Detailed refinement of the project level ToC</p>	<p>Comparative (realist) analysis</p> <p>Synthesis of project level findings</p> <p>Analysis of applicability of innovations to other settings / tenures / housing archetypes</p> <p>Programme level contribution analysis (with process tracing)</p> <p>Detailed refinement of the programme level ToC</p>
<p>6. Does the investment represent good value for money?</p>	<p>Analysis of costs data at programme and project level</p> <p>Analysis of data from projects and programme level evaluation about short term outcomes, and medium to longer term impacts</p> <p>Analysis of interviews with monitoring officers and project leads discussing their perceptions of the contribution of BEIS funding to different forms of additionality</p>	<p>Systematic Data Analysis</p> <p>CBA</p>	<p>Systematic Data Analysis</p> <p>Cost Benefit Analysis</p>

Q1 How effective were the BEIS grant competition and the technical support provided to projects during the programme?

This will draw primarily on qualitative data analysis, using analysis of programme documentation, and interviews with BEIS staff, MOs and Project Leads about the competition process to better understand the key lessons learned.

Q2 What is the learning about projects' design, development, and delivery?

We suggest qualitative data analysis here, drawing on information collected by projects as well as interviews with MOs and Project Leads. Table 4 (earlier in the report) provides the high level topics the interviews will need to focus on while Annex 4 – Full 'library' of evaluation questions provides more detail on the areas to cover.

At a project level, qualitative data analysis will help analyse the design and delivery of the projects, the factors shaping these, and help examine projects' delivery experiences.

At a programme level, a comparative analysis and synthesis of findings across the projects should focus on how design and delivery varies across contexts and what explains these differences.

Q3 How effective were the projects in achieving WHR at lower than normal costs?

BEIS's primary aim for the evaluation is to provide new, detailed, and robust evidence about which approaches, and business models are best suited to implementing WHR at scale, and which elements of the approach result in cost reductions. Consequently, any analysis of project and programme effectiveness should also focus on this.

We suggest addressing Q3 through qualitative data analysis, with specific focus on the questions highlighted in Table 4.

Both contribution analysis and process tracing will important methodologies for answering Q3. We provide more detailed explanations of what these both entail in the 'Proposed Methods' section below.

At a project level, we recommend **contribution analysis** to trace the contribution of different innovations to cost reductions. Evaluators should build on the initial cost reduction theory set out in the project level ToC, developing a ToC for each project, **focusing solely on cost reductions**. The contribution analysis techniques would underpin how that ToC is then tested to arrive at evidence-based explanations for the contribution of specific process innovations on costs. We also strongly recommend pairing contribution analysis with **process tracing** to add rigour to the analysis.

Data used in the contribution analysis might include projects' own data and documentation that track costs and sources of cost reductions, and the views of project leads, monitoring officers and partners on these.

At a programme level, we suggest comparative analysis and synthesis of findings from across the projects. The analysis should compare projects, examining why and how different innovations were deployed to generate WHR cost reductions, how these reflected different features of the contexts in which they were delivered, and how and whether they worked. To set the findings in context we recommend drawing on evidence from comparator WHR projects – either through evidence search / review or via direct consultation.

Programme level analysis should also include an examination of the relationships between, contexts, mechanisms and outcomes. However, as discussed below we do not specifically recommend the development and testing of prior 'realist hypotheses' of such project or programme level relationships.

Q4: What are the short-term outcomes?

We understand that projects will measure and analyse technical performance and outcomes (including for comparator homes to help assess the counterfactual) and may be able to provide pre-post installation data to the evaluators. Re-analysis of this raw data will help to assess the project-level outcomes seen. We suggest that the evaluators play a QA role, ideally accessing the raw performance and resident outcomes data and potentially re-running where necessary – ensuring assessments are robust but also undertaking any additional analyses that may help analyse short term outcomes and estimate the counterfactual. In particular, the evaluator could work with the respective projects to improve the rigour of any modelled or quasi-experimental designs used locally to assess the counterfactual and determine the net impact of the WHR installations on households. An aggregation of project level data will also help with the assessment of programme level outcomes and impacts.

We also anticipate further qualitative analysis of interviews with residents (whether undertaken by projects or evaluators) – to help understand the relationships articulated at a high level in the project ToC.

We also recommend undertaking a comparative analysis to explain the different outcomes across projects – building on an understanding of the different WHR installations, different housing archetypes, WHR retrofit approaches, different populations and contexts, and different measurement approaches adopted across comparators.

Q5: What are the (potential) medium and longer-term impacts?

We suggest using **contribution analysis** to assess the evidence for projects' potential contribution to medium- and longer-term impacts both locally (in the project area) and nationally (as set out in Table 3). The project and programme level ToCs illustrate the anticipated causal relationships of interest here.

At a project level the analysis should trace the contribution of project activities to key outcomes (e.g. improvements in project partners' capability and expertise, or increased interest in WHR amongst owner occupiers). The project level analysis should use interview data, and any project documentation that provides evidence of the behaviours expected if the project activities had indeed contributed to medium- and longer-term outcomes.

At a programme level there is value in comparing the outcomes across the different projects. As with Q3, any emerging patterns about the relationships between context, mechanisms and outcomes should be understood through proposed analytical methods set out in the next section. However, we do not specifically recommend the development and testing of prior 'realist hypotheses' about the relationships between project context (context), WHR installations / cost savings (mechanisms) and project level medium / longer term outcomes (outcomes) at project or programme levels.

We also recommend undertaking an overarching **contribution analysis** and **process tracing** (both explained in more detail later in this chapter) to examine the combined impact of the projects to national (programme level) medium- and longer-term impacts, as set out in Table 3.

An important, related requirement, is for an analysis of the likely applicability of the innovations deployed in the programme to both similar and different settings. This analysis could draw on data generated via the project level evaluations and in addition, use a wider review / consultation with other non-BEIS funded comparator projects.

Q6: Does the investment represent good value for money?

At a project and programme level, VfM can be assessed through an analysis of costs (of key inputs) and additional benefits (i.e. input, output, short term outcomes, and longer-term impacts). We provide further details on this approach in the next section.

Proposed methods

There are several theory-based methods that we believe are especially relevant to the WHR evaluation.

Realist evaluation

We do not propose a ‘pure’ realist evaluation – i.e. one that begins with a set of context mechanism outcome (CMO) hypotheses set out in matrices, all of which the evaluation should ‘test.’ Instead, we believe it is more appropriate to start with a theory of change and then build smaller evidence-based realist theories through the evaluation to explain observed results. The main reasons behind this are the difficulties in generating a plausible set of CMO theories in advance of the evaluation. Generating realist hypotheses requires evaluators to have a particularly good advance knowledge of a programme and particular interventions being deployed, along with (the relevant formal and practitioner theories that might underpin causal hypotheses), and a good understanding of the contextual features that might influence mechanisms and outcomes. The lack of detailed project level information makes it difficult to develop realist hypotheses now. Furthermore, it is unlikely to be achievable even during the evaluation’s inception phase unless there is scope for detailed engagement with project staff at each site, a critical review of the wider literature and theory, and engagement with other concurrent WHR projects. It would also be a somewhat risky strategy in the context of an innovation project, to build a detailed evaluation architecture around a set of fixed hypotheses around cause and effect given that any implementation plans many suddenly change making previous assumptions and hypotheses potentially redundant. There, a more agile and flexible theory-based framework is much more appropriate.

Given all this, we recommend the evaluators remaining alert to the value of developing realist theory to explain outcomes, but should not necessarily be an expectation or requirement of them. A realist lens is most likely to be applicable to Q3 (cost reductions seen), Q4 (short term outcomes) and Q5 (medium- and longer-term outcomes). For Q3 this might involve building theory as part of the programme level analysis to explain how and why different project contexts may have influenced the choice, delivery, and effectiveness of different cost reduction models. For Q4 and Q5, this might involve building theory to explain why benefits and outcomes were achieved in only some contexts rather than others (assuming there are such differences).

Contribution analysis

Contribution analysis³⁴ helps identify the relative contribution an intervention or sub-set of interventions has made to a given change. It aims to produce a credible, transparent evidence-based narrative of the contribution made of key cause and effect relationships in circumstances when there may be multiple factors beyond the intervention which influence

³⁴ <https://www.intrac.org/wpcms/wp-content/uploads/2017/01/Contribution-analysis.pdf>

outcomes and impacts. It is especially helpful where it is difficult to definitively quantify an intervention's contribution to an outcome because: (i) there are many different steps between activities and eventual desired changes; (ii) external factors often influence the changes brought about through the intervention; and (iii) because many different interventions (or different components within an intervention) can contribute to a single change.

Contribution analysis is generally used to test and refine one or two specific impact pathways – rather than to test all the impact pathways that might exist within a theory of change. It tends to be undertaken after a programme or project has been delivered. It progresses through 6 key steps which can be adapted according to requirements, as shown below. Steps 1-2 can be undertaken in advance but steps 3 to 6 are in practice undertaken after or during programme delivery.

1. Identify and focus on the causal issue
2. Develop ToC or (impact pathways) using existing evidence secondary and practitioner views³⁵
3. Draft the contribution story and highlight its main weaknesses / challenges
4. Gather new evidence from implementation and revise the contribution story
5. Obtain critical review of the contribution story (for example using peer evaluators)
6. Strengthen the contribution story

Early steps in contribution can be undertaken before an intervention is delivered, but the majority of the key steps tend to be undertaken after rather than before or during the delivery of an intervention.

Whilst its flexibility is an asset to its applicability, it also means that there are a variety of ways of implementing contribution analysis. It also relies heavily on qualitative judgements. This can affect the replicability of findings, which reinforces the need for peer review or other means of strengthening the analysis.

We recommend using contribution analysis to develop and test specific project and programme level impact pathways. For example, at a project level – contribution analysis could be applied to examine the relative contribution of different innovations to cost reductions for each project. At both project and programme levels, we recommend applying contribution analysis to examine the contribution of activities to medium- and longer- term outcomes of interest (e.g. demonstration effects, behaviours in the wider marketplace, national costs of WHR etc).

Process tracing

Process tracing shares many features with contribution analysis. Both seek to develop (causal) impact pathways to explain why changes occur, use relevant data to test these pathways, and develop alternative explanations for observed outcomes. Contribution analysis tends to be applied where programme or project activities contribute in multiple ways and forms over time. In contrast, process tracing is most widely used to test the strength of evidence for a single causal claim or hypothesis.

³⁵ In this case we have already developed the contribution framework for cost reductions (in the project level ToC) and the contribution framework for medium- and longer-term outcomes (in the programme level ToC)

While there are rigorous ways of applying contribution analysis, there are no particular ‘standards’ of evidence required. Process tracing on the other hand pays rigorous attention to the need to specify standards of evidence for testing particular hypotheses about **cause and effect** – in advance and, generally to work with stakeholders in the setting and application of these tests. Process tracing involve four types of causal tests³⁶, and describe the different ways evidence can be used to increase confidence in accepting or rejecting a hypothesis about causality:

- Smoking gun – the test is passed when the examination of a case shows the presence of a sufficient causal condition. Uncommon smoking guns are more persuasive than common ones
- Hoop test – the test is failed when the examination of a case shows the presence of a necessary causal conditions even when the outcome of interest is not present. Common hoop test conditions are more persuasive than uncommon ones
- Doubly decisive – the test is passed when the examination of a case shows that a condition is both necessary and sufficient to support an explanation. These tend to be rare
- Straw in the wind – this is an observation that lens support or an explanation without definitely ruling it in or out.

The tests are used to reduce error in supporting or rejecting causal claims. The tests can be performed in collaboration with stakeholders – to allow the strength of the evidence to be assessed transparently with stakeholders – much like in a legal context. The more tests the hypotheses are subjected to the stronger the case for whatever conclusions are drawn.

Key steps in process tracing include:

1. Identifying the change or changes to be explained. It is important to select a small number of changes for focus - prioritising where necessary.
2. Establishing the evidence for the change. Confirm the change has occurred – if in fact the evidence for the change itself is weak then there is no point proceeding further/.
3. Documenting the processes that are thought to have led to the change. Establishing hypotheses for all key causes linked to the change, and the conditions under which causal processes are expected to operate.
4. Establishing alternative explanations. Alternative explanations provide different hypotheses for observed changes.
5. Specify what kinds of evidence would strengthen or weaken the case for each of the hypotheses (i.e. the specific observations that represent the evidence tests outlined above for the specific hypothesised causal relationship).
6. Collecting and assessing the evidence for each causal explanation., evaluators must
Evaluators must collect data from both typical and deviant cases.

³⁶ <https://www.betterevaluation.org/en/evaluation-options/processtracing>

As with contribution analysis, most of the key steps in process tracing take place after intervention delivery rather than before.

'Bayesian updating'³⁷ **can** also be added to process tracing to further reduce risks of error but we do not think it is proportionate to add this additional layer of complexity on to an already complex analysis.

Using process tracing with contribution analysis

In recent years, studies have used process tracing in conjunction with contribution analysis to enhance the credibility of the analysis and causal claims³⁸. In this evaluation, we suggest using process tracing to improve the rigour of the contribution analysis – as outlined above. Doing so will strengthen the contribution analyses linked to cost reductions achieved by WHR, and help test the relationships between project(s) activities and medium / longer term benefits at both project and programme levels.

Any evaluation using contribution analysis and / or process tracing will need a theoretical framework to explain causal pathways for different outcomes and impacts – these being fundamental to these methods. In practice, the programme and project level ToCs already developed in this report provide this underlying theoretical framework. However, both ToCs are provisional, being based on a limited amount of available information. We recommend the evaluator further develops and refines the two ToCs during the evaluation inception, bringing in additional evidence especially around how the four individual projects operate. In addition, process tracing will require a pre-determining of the kinds of observations that would be expected to be made if the theorised relationships existed. Evaluators should specify these, building on the project and programme ToCs, ideally in collaboration with project participants. Additional data requirements that cannot be foreseen at this stage may flow from this.

Modelling of Energy and emissions savings and health outcomes

Estimates of emissions reductions can be calculated from reduced energy consumption (i.e. increased energy efficiency) arising from WHR installations. We anticipate that project leads can provide estimates on these. The identification of net emissions reductions should be carried out in line with the Green Book Supplementary Guidance on the valuation of energy use and greenhouse gas emissions³⁹.

Best practice for project lead emission valuation estimates will contain energy consumption reduction disaggregated per fuel where applicable (expected to be natural gas, electricity or in some cases, fuel oil). Resultant net emission savings can then be calculated by applying BEIS

³⁷ Bayesian updating is a quantitative measure of one's confidence in the steps of the causal mechanism by assessing their probative value according to sensitivity (the probability of observing the piece of evidence if the step in the causal mechanism is true) and specificity (the probability of observing the same piece of evidence if the step in the causal mechanism is false). See the International Institute for Environment and Development (207) at <https://pubs.iied.org/17402IIED/>

³⁸ See for example Delahais, T, Toulemonde, J. et al (2017) 'Making rigorous causal claims in a real-life context: Has research contributed to sustainable forest management' in Evaluation, 23 (4) and Befani, B., & Mayne, J. (2014). Process Tracing and Contribution Analysis: A Combined Approach to Generative Causal Inference for Impact Evaluation. IDS Bulletin, 45, 17-36.

³⁹ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/794737/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal-2018.pdf

carbon emissions and energy conversion factors⁴⁰ and the value of carbon for use in policy appraisal and evaluation⁴¹

Following the Green Book guidance involves identifying a robust counterfactual scenario for WHR implementation. Using the household as an analytical unit, an appropriate counterfactual could be the consumption patterns prior to the installation of the WHR. Consumption reduction estimates will be most accurate when based on comparison of year on year data, using monthly consumption figures (use of more granular daily, hourly or half hourly data is preferable). Some projects already plan to use technology and modelling to estimate the counterfactual in such a way.

We recommend that a critical review of energy and emissions reductions is provided as part of the evaluation. The review will involve checking the methodology used (by projects) to calculate energy consumption reductions, the accuracy of calculations, input assumptions, and analysis relating to the confidence level that the retrofit has caused any reductions in energy consumption.

Effective identification of the confidence level will require analysis to correct raw consumption data for the effects of weather (using degree days). Further correction may also consider behavioural factors (such as the number of household occupants, affluence of household occupants, other specific identified usage patterns).

Project lead estimates may also identify that WHR installations do not reduce electrical consumption but change usage patterns to take account of reduced economy 7 or other novel time of use tariffs. In this case, modelling to identify whether there is a net emission reduction would need to identify specific profiles of consumption and identify temporal changes in grid-emissions factors.⁴²

The respective projects are expected to directly measure health and resident outcomes and the evaluation inception phase should explore the appropriateness of these plans in further detail. We also recommend exploring the potential for modelling improvements in health outcomes, namely Quality Adjusted Life Years (QALYs) linked to reduction in excess winter deaths, or diagnoses of mental health conditions. The respective projects may also directly measure health and resident outcomes the evaluation inception phase should further explore.

VfM assessment

A proportionate cost-benefit analysis (CBA) will help to understand how far the WHR programme represents a value for money approach to finding and demonstrating cost reductions for large scale whole house retrofitting. We suggest conducting both project and programme level CBAs. Given that each of the projects are expected to adopt distinctive WHR approaches, there is value in understanding the value for money associated with each of these individual approaches. However, it is equally important to understand the programme's CBA (i.e. the aggregated cost benefits of the projects, as well as the wider 'national' benefits of the programme).

The CBA will need to ensure that programme benefits and programme costs are not double-counted – to that end, the programme level CBA should not simply be the aggregate of the

⁴⁰ <https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting>

⁴¹ <https://www.gov.uk/government/collections/carbon-valuation--2>

⁴² <https://carbonintensity.org.uk>

project level ones. For example, two projects are based in London meaning that certain supply chain/local industry benefits might be double counted.

The CBA will need to produce outputs including:

- Net Present Value (NPV): The net present value is the sum of the present values of the net benefits (or costs) incurred over the study period. An NPV greater than 0 represents a positive programme investment.
- Benefit-Cost Ratio (BCR): The benefit-cost estimates identify the quantified monetised value of benefits that will be achieved for a single unit of cost. A programme with a BCR greater than 1 represents a positive programme investment.
- Evaluation of payback periods: The period in which the NPV changes from negative to positive is known as the payback period, and measures how long the programme will take to "pay for itself".

Evaluators should conduct both the project and programme CBAs in accordance with the HM Treasury Green Book⁴³ including Green Book Supplementary Guidance⁴⁴. This centres on identifying a suitable counterfactual to assess whether the expected effects could have occurred in the absence of the WHR programme. In principle, we believe that there are three counterfactual scenarios that the evaluation could consider.

- Comparing households that do have WHR installations against those that don't
- Comparing non-WHR programme funded projects with those that did receive programme funding
- What regional or national level effects would have occurred in the absence of the programme.

The small number of projects supported, as well as the limited number of unsuccessful applicants mean that there are no obvious opportunities to undertake a robust quasi-experimental counterfactual assessment (such as regression discontinuity design or difference in difference) for these three counterfactual scenarios. There will also need to be a consistent estimation of the counterfactual across the different projects. With respect to short term household outcomes, this counterfactual would need to be theoretical - unless the projects collect their own data from comparator households with (which could therefore act as an empirical counterfactual). Such a theoretical counterfactual would be based on scoping work to agree a 'business as usual' scenario, assuming the WHR programme had not been introduced, and the energy efficiency and cost reduction gains continue in line with projected estimates to 2030, taking into account the estimated effects of other known policy interventions.

Whilst the short-term benefits set out in Table 3 should be known by the time the CBA is undertaken, medium and longer term ones may need to be estimated using wider evidence as they may not be seen until long after the evaluation. To conduct a CBA on the programme in 2021, ex-ante projections will be required for forecasted costs and benefits to be incurred between 2021 and the end of the CBA time horizon (expected to be 2030).

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https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

⁴⁴ <https://www.gov.uk/government/collections/the-green-book-supplementary-guidance>

Evidence based sensitivity analysis will be required to provide a range of values to account for any key uncertainties identified (e.g. the level of cost reduction achieved by WHR projects, the economies of scale associated with the increased repeatability of implementation).

Below, we discuss the anticipated costs and benefits to BEIS at both the project and programme level. We anticipate that in many cases, cost and benefit information will come from project monitoring data, individual project completion reports and/or project level interviews although in some cases, evaluators may need to work with programme and project stakeholders to develop suitable assumptions. At a minimum however, evaluators will need to obtain credible data for each project on project management and implementation costs, carbon emission savings, and reduced costs in undertaking WHR given that these data are also central to the programme level CBA.

Table 8 Programme level costs and benefits

Cost / Benefit	Metric	Further details
Cost	Programme management costs	Includes BEIS project team costs and other in-kind costs
	Programme implementation and evaluation costs	Cost of grants and any other funding provided to the projects
	Costs of stakeholder engagement	e.g. briefing sessions with suppliers and local authorities, resources used in wider industry engagement
Benefits	Reduced carbon emissions	To be based on estimates produced by the different projects. The government has agreed a set of carbon values to be used in policy appraisal and evaluation. ⁴⁵ This allows for the valuation of net carbon emission savings.
	Improved energy efficiency of homes	Changes in EPC ratings
	End-user cost reductions	Reductions in heating and healthcare costs for residents
	Health benefits	This could be assessed by measuring the cost improvement per Quality Adjusted Life Year (QALY) ⁴⁶
	Increased investment in WHR solutions	Should consider level of public investment in new or existing WHR programmes, and levels of industry interest in implementing WHR programmes

⁴⁵ <https://www.gov.uk/government/collections/carbon-valuation--2>

⁴⁶ Further details on QALY are available on Department for Health (2010) 'Quantifying health impacts of government policies.' Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/216003/dh_120108.pdf (accessed 30 April 2020)

	Reduced costs in undertaking WHR	The reduced infrastructure, materials or labour costs associated with implementing process innovations introduced because of the WHR programme.
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Table 6 Project level costs and benefits

Cost / Benefit	Metric	Further details (where appropriate)
Cost	Project management costs	BEIS project team costs involved in management and oversight of project. Also needs to include monitoring and management resources by delivery partners
	Project implementation costs	<ul style="list-style-type: none"> • Community engagement costs • Costs involved in developing new retrofitting solutions or approaches • Costs of engaging with supply chain
Benefits	Carbon emission savings	Using a valuation of net carbon emission savings as outlined above applied to project level calculations of actual reductions in energy consumption. Should include: <ul style="list-style-type: none"> • Savings through more carbon efficient retrofitting techniques • Savings seen by residents of retrofitted homes
	Reduced household energy consumption	Project monitoring should provide actual reductions in energy consumption following installation. BEIS estimates or energy prices may help identify projected savings.
	Production cost savings	Achieved through new technologies or methodological approaches adopted through the project Future production cost savings resulting from demonstration of lower average costs of WHR.
	Improved market value of the property	For social housing, these could either be a valuation used for council tax banding, or the value of the property as a financial asset for councils/landlords.
	Reduced costs in undertaking WHR	The reduced infrastructure, materials or labour costs associated with implementing process innovations introduced because of learnings from the WHR programme.

A CBA is central to any VfM assessment. However, VfM assessments need to consider not only the quantifiable and monetizable effects of an intervention, but also its contribution to more strategic goals. At the project level for example, VfM assessment will also need to

consider how far these projects also produced national level benefits given the intervention's focus on informing the national WHR sector. Contribution analysis will help in understanding this. As outlined in Section 2, there are already a number of concurrent / existing WHR projects which could be a benchmark for each project's performance. If comparator projects are also producing national-level benefits, then it would demonstrate that the WHR programme is not the only factor shaping WHR approaches across the country.

At the programme level, the VfM assessment should also take into account the programme's national ambitions - this includes catalysing wider benefits including enhanced capabilities, its influence on new projects delivered at lower costs, new investment, and new innovation.

7. Estimated evaluation costs and timelines

Estimated costs

Table 7 provides an initial cost estimate undertaking the WHR retrofit evaluation. The work takes place in three phases:

- **Phase 1** centres on understanding more about the individual projects, updating assumptions about the programme, and refining the research and evaluation plan
- **Phase 2** which assesses the programmes and projects when project delivery is completed (currently assumed to be March 2021). This will largely focus on the process evaluation while also providing some initial impact evaluation evidence.
- **Phase 3** which will take place on programme completion (currently assumed to be September 2021). This will focus on the impact evaluation but also provide additional process evaluation evidence where it is available.

We provide cost estimates for three evaluation options:

- Option A is the ‘minimum viable product.’ While it will collect all the data required, it will approach the evaluation in a light-touch and less thorough manner. For instance, it dedicates less time to working with the projects to develop evaluation plans, has fewer interviews, and will only produce case vignettes for each WHR project
- Option B is our recommended option. Compared to Option A, it budgets for greater time working with the projects to develop evaluation plans, and makes provision for a workshop to develop a programme level Theory of Change. Option B also includes more interviews (including with comparator programmes) and resident interviews. It also includes more detailed analysis of each project – dedicating a report chapter to each one. While the level of effort and analysis is less than for Option C, it places less of an administrative and resource burden on the respective projects, and can also take place within BEIS’ preferred timeframe.
- Option C is the most comprehensive evaluation option. Compared to Option B, it offers greater resource still for working with the projects, and assumes workshops to develop each project’s ToC (as opposed to a single programme level workshop in Option B). It also allows for much more detailed data analysis compared to Option B (hence greater resources available for reporting), and also incorporates individual evaluation reports for each project. Given the additional work required, we also include additional budget for project management and meetings. While Option C will provide the most detailed evaluation analysis, it will also require much greater time and involvement from the project managers at a time when their natural focus will be on project delivery and implementation. The additional time required to deliver Option C also presents risks in delivering the evaluation within the timeframe favoured by BEIS.

Table 7 Indicative evaluation costs (excluding VAT)

Work strand	Option A cost (minimum viable product)	Option B cost (recommended)	Option C costs (comprehensive)
Phase 1 – Inception and evaluation planning with projects			
Scoping interviews (stakeholders and project leads)	£4,000	£10,000	£11,500
Review programme documentation / data gap analysis	£5,000	£6,500	£6,500
Comparator assessment	£3,000	£3,000	£4,500
Baseline assessment	£4,000	£4,000	£5,500
Update project and programme ToC (inc. workshops for Options B and C)	£5,000	£6,500	£11,000
Develop research tools	£4,000	£4,000	£4,000
Work with projects to design tools for counterfactual and impact assessment (.e.g resident feedback)	£9,000	£9,000	£9,000
Finalise evaluation plan (incl. contribution analysis and process tracing framework)	£10,000	£11,000	£12,000
Phase 2 – Assessment at project delivery completion			
Review data and reports prepared by projects	£5,000	£5,000	£5,000
Interviews with project leads	£1,500	£3,000	£3,000
Interviews with MOs	£3,500	£3,500	£3,500
Interviews with project consortium members and stakeholders	£4,500	£5,000	£6,000
Comparator assessment	£3,000	£4,500	£4,500

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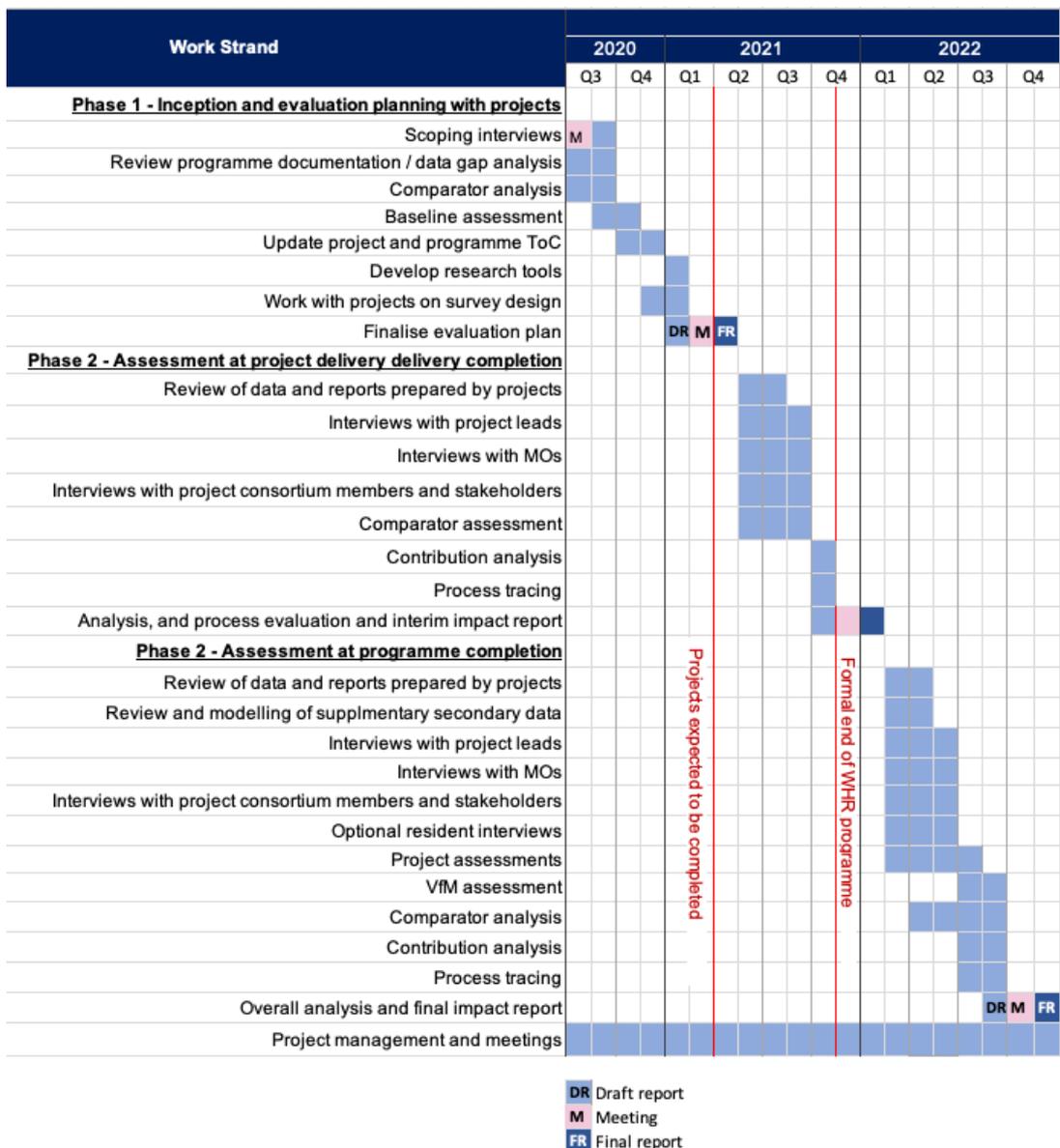
Contribution analysis (for RQ3)	£5,000	£8,000	£12,000
Process tracing (for RQ3)	£5,000	£8,000	£12,000
Analysis, and process evaluation and interim impact report	£8,500	£12,000	£24,000
Phase 3 – Assessment at programme completion			
Review of data and reports prepared by projects	£6,000	£6,000	£7,500
Review and modelling of supplementary secondary data	£0	£6,000	£6,000
Interviews with project leads	£1,500	£3,000	£3,000
Interviews with MOs	£3,500	£3,500	£3,500
Interviews with project consortium members and stakeholders	£4,500	£4,500	£6,500
Optional resident interviews	£0	£9,000	£9,000
Project level reporting (Option A – case vignettes, Option B – report chapters, Option C – full reports)	£5,000	£10,000	£19,000
VfM assessment	£6,000	£6,000	£6,000
Comparator analysis	£3,000	£6,000	£6,000
Contribution analysis	£5,000	£8,000	£12,000
Process tracing	£5,000	£8,000	£12,000
Overall analysis and final impact report	£10,000	£13,500	£13,500
Cross-phase costs			
Project management and meetings	£6,000	£10,500	£19,000

Total cost	£137,000	£197,000	£257,000
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Indicative evaluation timings

The Gantt chart below provides indicative timings for the evaluation (for Option B), recommending evaluation commencement in Q3/Q4 2020 with fieldwork phases commencing in Q2 2021 and Q4 2021. We also suggest a final report due in Q4 2022. We base these timings on the assumption that BEIS is able to launch the evaluation commissioning processes in mid-to-late 2020, that project delivery completes by March 2021, and that the programme completes in October 2021. The second two milestones may change in due course as projects respond to challenges associated with the COVID-19 pandemic. This Gantt chart may therefore need revisiting and altering during the evaluation’s commissioning and inception stages.

Figure 3 Indicative timings for the WHR evaluation (Option B - recommended)



Annex 1: List of potential KPIs

Here, we provide a list of KPIs that SICE uses for all of its innovation programmes. We understand that all WHR projects will need to provide data for all these KPIs except KPI 5, 7i and 7iii which are not relevant to the programme.

Table 8 List of SICE KPIs

	Description
KPI 1 (programme level)	Number of Energy Innovation projects supported- completed
KPI 2 (programme level)	Number of projects that have successfully met objectives
KPI 3	Number (and size) of Organisations supported to deliver project (Lead Partner and Other Organisations as named on grant offer/ contract)
KPI 4	Number of active Business Relationships and Collaborations supported (Formal and Informal, Overall and New)
KPI 5	Advancement of Low Carbon Solutions- Technology Readiness Levels
KPI 6i	Initial Financial Leverage from private sector to deliver project
KPI 6ii	Follow-on Funding to take project further forward
KPI 7i	Reduced Unit Cost of energy- LCOE Potential Reduced Unit Cost up to 2032
7ii	Increased Energy Efficiency/ Reduced Energy Demand Potential Increased Energy Efficiency up to 2032
KPI 7iii	Increased energy system flexibility Potential Increased Energy System Flexibility up to 2032
KPI 8	Number of products (and services) sold in UK and Internationally
KPI 9	Potential reduction in CO2 emissions savings of project up to 2032

Annex 2 Collection of data on resident outcomes

Table 9 Project plans to collect resident outcome data

Project 1	Health and wellbeing surveys will be undertaken pre- and post-retrofit by an independent research organisation
Project 2	The project will conduct a combined satisfaction and health questionnaire and target completion for 80% of homes.
Project 3	A baseline study will be carried out prior to the works to ascertain occupants' views about their homes in terms of comfort, energy, health and well-being, and their expectations about the refurbishment project. This would use a questionnaire, focus groups, interviews and visits. A follow up study 12 months after completion to assess longer-term impacts would use a second questionnaire and another round of interviews and focus groups, in conjunction with monitoring data.
Project 4	The project will include a baseline study, carried out prior to the works to ascertain occupants' views about their homes in terms of comfort, energy, health and well-being, and their expectations about the project, as well as a follow-up study carried out post completion – preferably towards the end of the heating season – to provide a more holistic assessment of the impact of the retrofit programme in the longer term. The above will use a mixed methods approach to provide both quantitative and in-depth qualitative data – including a questionnaire to all residents, focus groups, interviews and visits both before and after retrofit.

Annex 3 – Project’s plans for technical performance assessment

Table 10 Project plans to assess their own technical performance

Project 1	<p>The project will collect data from the following sources, pre-retrofit:</p> <ul style="list-style-type: none"> Energy bills over a 24-month period, collected from at least 60% of homes EPCs, representing all homes (i.e. not unnecessarily surveying near-identical homes) Heating system type and efficiency Solution provider modelling of existing homes <p>Post retrofit, the project will use an established monitoring protocol. This includes:</p> <ul style="list-style-type: none"> Energy consumption data EPCs, representing all homes Solution provider modelling of retrofitted homes. <p>As there will be some estimation in the pre- and post-retrofit, this will be cross-referenced with heat-loss coefficients for 10 homes with at least 2 months of winter data. The 10 homes will be sampled to provide the greatest confidence in the results obtained across all phases of the project.</p>
Project 2	<p>There are eight steps:</p> <p>Step 1: Establish building performance under current occupancy and use ‘as is’ including a combination of: utility bills, short-term in-situ monitoring; physical testing e.g. air tightness testing, U-values, thermographic survey – singularly or in combination with pulse testing.</p> <p>Step 2: Development of dynamic simulation model, based on measured or design drawing information, and details of the existing energy strategy, including: ‘as built’ spec and tests, measured air tightness, measured U-value, on-site climate data.</p> <p>Step 3: Refine simulated information to improve model accuracy by comparing the results of modelling with any known information (e.g. monitored data and energy bills).</p>

	<p>Step 4: Assess theoretical performance improvements through manipulation of the simulation model to reflect the changes.</p> <p>Step 5: Monitoring procedure is repeated post fabric/system upgrade under occupancy conditions.</p> <p>Step 6: Compare and analyse predicted and measured performance of actual building and model and any differences in the model assumptions can be adjusted by physical measurements if required.</p> <p>Step 7: Calibration of dynamic simulation model comparing predictions with actual measurements and existing data, or using a standard Pulse Test methodology if building unoccupied.</p> <p>Step 8 Final calibrated model used as the basis for three dynamic simulation model variations – as built building performance; basic building performance, using minimum building regulation fabric performance and conventional energy supply; future building performance, anticipating how the building would perform with upgraded fabric and services.</p> <p>Sampling technique: recommend testing of mid- and end-terraced properties in exposed and sheltered locations in as many orientations as possible and with a variety of demographics (family/single person/couple; out all day/home all day; shorter/longer temperature regime). Anticipate modelling / monitoring on 6-12 dwellings with 2 or 3 variants per building</p>
<p>Project 3</p>	<p>The team will conduct an initial pre-retrofit thermographic assessment during the winter period prior to retrofit commencement. 20% of dwellings in the project will be assessed. Sampling will be systematic, to include properties from both archetypes, a range of dwelling sizes, occupancy patterns and tenure. The goal is to maximise sample diversity across the selected stock. Similar samples will be coupled in order to provide a direct and consistent comparison for identification of anomalous results. Air permeability tests, thermal imaging (external and internal) will also be undertaken. The above tests will all be conducted post-retrofit, in matched weather conditions, ideally by the same assessor. The project will also apply dynamic simulation modelling with ‘short-term’ pre and post dwelling monitoring. Performance evaluation will also include in-situ U-value testing (pre- and post-retrofit) of external walls at 2 dwellings within the project. The monitoring equipment will also be used to undertake longer-term ‘in use environmental monitoring’, both pre- and post-retrofit, to support the assessment of improvements to internal environmental conditions, thermal comfort, and air quality related conditions. An</p>

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	additional 4 dwellings will undergo similar longer-term monitoring prototype sensors that will monitor temperature, relative humidity, CO2, NO2, PM2.5 and VOC.
Project 4	For the first workstream, the following monitoring data will be collected from all homes: space heating, DHW, small power, environmental sensors that record temperature and humidity, PV generation, use and export, battery efficiency, heat generated and heat used. The second workstream will collect heat and humidity data from environmental sensors for 100% of properties, space heating, DHW and small power in a 25% sample.

Annex 4 – Full ‘library’ of evaluation questions

Table 11 Full list of questions for the evaluation to answer

High Level question	ToC reference	Level of evaluator effort required	Project level sub-questions	Programme level sub-questions
1 How effective were the BEIS grant competition and the technical support provided to projects during the programme?	PG1	Low	<ul style="list-style-type: none"> • How and in what ways did the competition influence the design of the project • How and in what ways do project leads believe the competition design be improved? • How helpful have project leads found the support provided to them over the projects’ duration? 	<ul style="list-style-type: none"> • What was the rationale for the approach taken? What alternatives were considered and why were they ruled out? • Did the competition secure sufficient viable bids from organisations most capable of delivering the ambitions of the programme? • What learning is there for future programmes about what might be needed to attract the type and number of projects? • Did the technical support provided to projects contribute to their effectiveness? • How effective was the project monitoring role?
2 What is the learning about projects’ design, development, and delivery?	PJ1	High	<ul style="list-style-type: none"> • WHR technicalities • What were the core elements of the technical approach to WHR? 	<ul style="list-style-type: none"> • What are the main differences in the design and implementation of WHR approaches across the projects • Why did they differ in these ways?

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			<ul style="list-style-type: none"> • What was the rationale for the approach? • What housing archetypes were involved? • What forms of technical innovation did the project introduce? • How effective were the processes used to deploy multiple individual fabric retrofit measures and their integration in the house? • What challenges were there in delivering the retrofit solutions? • How effective were the methodologies for assessing technical performance? • How will energy performance be monitored beyond the life of the project? • More broadly • How did contextual factors influence decisions made, and the effectiveness of implementation? 	<ul style="list-style-type: none"> • How viable are different (technical) approaches to WHR in different circumstances? • What is the wider learning from across the projects about running a large scale WHR project?
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			<ul style="list-style-type: none"> • What impact did key elements⁴⁷ of the project have on successful project implementation? • Across design, planning and delivery – what were the main changes experienced? • How were these challenges overcome? • What learning is there about required skills and organisational relationships needed to deliver large scale WHR? 	
3 How effective were the projects in achieving WHR at lower than normal costs?	PG2 -6 & PJ 2-7	High	<ul style="list-style-type: none"> • What was the difference between anticipated and actual costs? • What were the main process innovations? • To what extent were project innovations delivered? • What impact did each of the process innovations have on costs? 	<ul style="list-style-type: none"> • What explains any differences in cost reductions achieved across the projects? • What are the main sources of cost reductions across the sites? • How do cost reductions compare with those found in other programmes? •

⁴⁷ Such as resident engagement, quality assurance and mitigation strategies, technical measurements, and hand over arrangements

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			<ul style="list-style-type: none"> • What other factors influenced project costs – positively / negatively? 	
4 What are the short-term outcomes?	PJ 10-18	Moderate	<ul style="list-style-type: none"> • What were the project's technical performance and resident outcomes? • How were these outcomes generated? • How were unintended negative outcomes identified and managed? 	<ul style="list-style-type: none"> • How do (short term) project-level outcomes vary across projects? • What explains this variation? • What is the contribution of the programme to these outcomes?
5 What are the (potential) medium- and longer-term outcomes?	PJ19-24 and PG 7-13	High	<ul style="list-style-type: none"> • What are the medium- and longer- term impacts at the project level (actual if possible, anticipated if not)? • What explains these outcomes? • What outstanding challenges and obstacles stand in the way of more ambitious WHR packages in similar or different contexts? 	<ul style="list-style-type: none"> • What explains any differences in estimated / actual medium- and longer-term outcomes for projects? • What are the (estimated) national / programme level outcomes? • What is the combined contribution of the projects to national outcomes? • What explains the medium and national effects? • To what extent have projects' dissemination activities contributed to the overall demonstration effect?
6 Does the investment represent good value for money?	All benefits specified in the ToC (and	Low	<ul style="list-style-type: none"> • What other sources of funding were brought into the project? 	<ul style="list-style-type: none"> • What did the BEIS funding achieve? • Does the net present value of benefits outweigh the programme costs?

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	<p>inputs not included in ToC (see VFM section later in report)</p>		<ul style="list-style-type: none"> • How would the project have looked in the absence of BEIS funding? • What input, output, outcome and behavioural additionality can be attributed to BEIS funding? 	
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