Department for Energy Security & Net Zero

Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D))

Joint Outcome and Economic Evaluation Report

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List of Abbreviations

BEIS	Department of Business, Energy and Industrial Strategy
CWI	Cavity wall insulation
DESNZ	Department for Energy Security and Net Zero
DLUHC	Department for Levelling Up Housing and Communities
DORIC	Domestic Optimised Retrofit Innovation Concept
DPC	Damp proof course
DWP	Department for Work and Pensions
EPC	Energy performance certificate
EPS	Expanded Polystyrene
EWI	External wall insulation
IMD	Index of Multiple Deprivation
IWI	Internal wall insulation
LED	Light Emitting Diodes
LPG	Liquefied petroleum gas
MEV	Mechanical extract ventilation
MVHR	Mechanical ventilation with heat recovery
NAO	National Audit Office
ONS	Office for National Statistics
QCA	Qualitative comparative analysis
RLO	Resident Liaison Officer
SAP	Standard Assessment Procedure
SHDF	Social Housing Decarbonisation Fund
SHDF(D)	Social Housing Decarbonisation Fund Demonstrator
TOC	Theory of Change
WHR	Whole House Retrofit

Executive Summary

The Department for Energy Security and Net Zero (DESNZ, formerly the Department for Business, Energy and Industrial Strategy (BEIS)) commissioned a joint process, outcome and economic evaluation of the Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund (Demonstrator) (SHDF(D)) programmes to run from February 2021 to August 2023. This report covers the outcome and economic evaluation. Due to the small size of the programmes, particularly WHR, findings discussed in the report are common to both programmes; where findings are unique to one of the programmes, this is made explicit.

Building upon the process evaluation published in June 2023,[1] this report:

- Assesses whether outcomes, including lessons learned, have been achieved from the implementation of WHR and SHDF(D).
- Provides policymakers and project teams with a greater understanding of the potential impact of such programmes.
- Discusses how specific design choices and contexts affect different outcomes.

The research covers the programmes' inception, delivery, and project closure and post-closure activities over the period February 2021 to 30 June 2023.

Background

Both the WHR and SHDF(D) programmes required a deep approach to retrofit (reducing the property space heating demand through the implementation of multiple energy efficiency measures), with a challenging space heating demand target of 50kwh/m2/year. This is distinct to the currently ongoing SHDF Main Fund. While the Main Fund allows applications with such approaches to retrofit for landlords that wish to do them, the Main Fund has a greater focus on delivery at scale of retrofit within a given grant funding amount, supported through design features such as less challenging space heating requirements and the introduction of cost caps. The findings of this report are therefore specific to the deployment of deep retrofit approaches taken in SHDF(D) and WHR. Chapter 9 details the lessons generated from both programmes which have fed into the design and implementation of the SHDF Main Fund.

The WHR programme was launched in June 2019 and was initially intended to close by April 2021, but was later extended to 30th June 2022 to account for the unanticipated effects of COVID-19. Following this, the two remaining WHR projects, Destination Zero I and

[1] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008. Available at: https://www.gov.uk/government/publications/whole-house-retrofit-and-social-housing-decarbonisation-fund-demonstrator-joint-process-evaluation

Energiesprong Sutton were both granted extensions to November 2022 and April 2024, respectively.

SHDF(D) launched at the end of September 2020 and intended to close by December 2021 but was extended to December 2022 to account for the continued effects of the pandemic on delivery, among other reasons explained below. Out of the 20 SHDF(D) projects which were initially selected for funding, one dropped out before receiving the funding, five withdrew during delivery, nine had closed at the time of writing this report in June 2023 and a further five were in progress. Out of the four WHR projects which were initially selected for funding, one dropped out, one later withdrew, one had closed at the time of writing and a further one was still in the process of retrofitting. The Table below provides an overview of the two programmes.

Table: Overview of WHR and SHDF(D)

Characteristic	WHR	SHDF(D)
Funding allocated (including for withdrawn projects)	£7.7m	£62m
Total final DESNZ expenditure	£2.8m	£38m
Total final expenditure (DESNZ + match funding)	£7.1m	£83.8m
Tenure type targeted	Any (though only social housing projects were selected for funding)	Social housing only[2]
Space heating performance target	30-50 kWh/m2/yr	50 kWh/m2/yr
Install cost-reduction target	5-15%	5-30%
Total projects	2 (originally 4)	14 (originally 20)
Initial target number of properties	396 (470 including properties from the 2 withdrawn projects)	1,738 (2,369 including properties from the 6 withdrawn projects)
Final target number of properties (August 2023)	74	1,276

[2] As per Competition Guidance for the SHDF(D) programme: “The focus must be on social housing. Where leaseholder or freeholder (right to buy) properties are included grant and match funding must be used on those properties, without costs being passed on to leaseholders/freeholders.”

Characteristic	WHR	SHDF(D)
Completed properties (August 2023)	64 (10 still to complete)	1,143 (133 still to complete)
Initial programme timeframes	June 2019 – March 2021 (1.5 years)	September 2020 – December 2021 (1 year)
Final programme timeframes	June 2019 – March 2023 (3.5 years) with residual delivery ongoing at the time of writing	September 2020 – December 2022 (2.3 years) with residual delivery ongoing at the time of writing

Source: DESNZ reporting at the time of writing (June to August 2023). The final target number of properties, completed properties and properties still to complete have been updated to the latest available data (August 2023). For consistency at the time of analysis, the report otherwise reports on the total number of properties (completed and still to complete retrofits) as of April 2023. As of April 2023, the final target number of (SHDF(D)) retrofits was 1,293 properties and 20 communal spaces, with 1,143 completed and 180 still to complete. There is no change between April and August data for WHR.

This outcome and economic evaluation takes a mixed methods and theory-based approach. It draws upon:

- Project reporting and management information up to June 2023;
- Externally sourced secondary data relating to employment of participating companies, the typical energy performance of installed measures and their associated costs;
- A survey of 256 residents receiving installations, 56 depth interviews with participating residents, and an ethnographic video diary also with residents receiving installations;
- 96 interviews with project delivery teams, 12 interviews with DESNZ delivery teams, eight interviews with organisations involved in the whole house retrofit market (solutions providers, industry experts and practitioners);
- Thermal efficiency and energy savings modelling;
- Costs analysis and value-for-money analysis and a qualitative comparative analysis (QCA).

Although this outcome and economic evaluation report draws from multiple sources of primary and secondary data, it is still subject to some limitations. The short time-period between the closure of projects and data collection for this evaluation has limited the ability of the evaluation to collect data on outcomes for all projects. Where projects remain ongoing, this has also affected the availability of complete monitoring data. This has reduced the comparability of findings between projects, and, in some cases, it was not possible to collect data on actual outcomes / change so the findings are modelled instead. These limitations particularly affect the ability of the evaluation to draw conclusions on long-term energy, carbon and bill savings, job impacts and resident outcomes such as ongoing well-being and energy use behaviour.

Key findings: WHR

As of June 2023, two WHR projects had completed retrofits with 64 properties installing 256 measures. At the time of writing, one of these projects (Destination Zero I) is closed and one is completing a small number of retrofits (Energiesprong Sutton).

Responding to the competition requirement, both WHR projects aimed to test the hypothesis that retrofit at scale (200+ properties) with innovation in whole house retrofit can reduce the cost per property of such deep retrofit,[3] through economies of scale and generating learnings on where and how to save costs. However, at the time of writing both projects had reduced the original scale they set out to achieve by more than 70% meaning that the final number of properties being retrofitted under the programme is 74.

WHR projects installed loft insulation at all properties, and external wall insulation (EWI) at the majority of properties. The most common combination of measures was EWI and loft insulation, which applies to 66 out of 74 properties.

A total of 73[4] out of 74 of the properties retrofitted / being retrofitted under WHR achieved or were modelled as likely to achieve up to EPC band A or band B.

Key findings: SHDF(D)

As of June 2023, 14 SHDF(D) projects had completed retrofits with 1,143 properties covering 5,182 measures. At the time of writing, five projects had yet to close.

Amongst SHDF(D) projects, the three most commonly installed measures were EWI (n=949 properties), loft insulation (n=797), and new windows (n=769). Many properties also had heat pumps installed (n=489), doors (n=428), and solar PV (n=346). Whilst there are some anomalies in the data affecting accuracy (see Technical Annex), projects implemented – on average – 4.5 measures per property. Over three-quarters (98%) of completed properties (for which there is sufficient data available) were estimated to have achieved EPC C or higher, of which 13% were estimated to have achieved EPC A.

Overall conclusions (applies to both WHR and SHDF(D))

Scale: As of June 2023, five out of 16 projects were able to deliver retrofit to the original number of properties targeted. For WHR, no project achieved either the initial target number of

[3] The WHR programme set a programme requirement that projects had to aim to retrofit at least 75 properties, with Energiesprong Sutton setting a target of 100, and Destination Zero 1 setting a target of 180 properties in their applications for funding.
[4] Information from one property in WHR Destination Zero I is missing.

properties as set out in their application, nor the target outlined in the programme ITT.[5] Therefore, the two WHR projects did not achieve retrofit 'at scale'. This was primarily due to inflationary pressures, limited supply chain capacity, and unanticipated enabling and remedial works.

Resident satisfaction: Overall, residents who had their properties retrofitted were satisfied with the results and perceived a range of benefits from the experience, with almost two-thirds (59%, n=145) of those surveyed being very or fairly satisfied. Benefits typically comprised improvements to how comfortable they felt in the home, the home aesthetics and subsequent effects on their health (mental and physical). Of residents participating in the survey and whose retrofits were completed, 68% (n=102) agreed that 'my property is more comfortable to live in' and 63% (n=95) agreed that 'my home is a nicer place to live'.[6] In the qualitative research, residents said that their homes now felt warmer for longer. For example, some described that they no longer needed to wear extra clothing or use extra blankets in the winter months.

> *"This year me and my wife have actually slept in our own bedroom this winter. Although it has still been slightly cold, it wasn't as cold as it was… We have spent more time in the front room this winter than any other winters." Resident (AppLife mobile diary research)*

A small number of residents also described some adverse changes in their experience of the home, which they considered to have resulted from the retrofit, or the retrofit process. These included new issues with the home arising post-retrofit. When considering the survey, resident interviews, and mobile diary evidence together, disbenefits of the retrofits appear to have been either minimal, anomalous, or outweighed by the perceived benefits of the retrofit.

Energy savings, carbon emissions reductions, and energy bill savings: The modelled data found that properties retrofitted under both programmes achieved energy savings, carbon emissions reductions and energy bill savings. On average, properties retrofitted under the two programmes:

- Achieved modelled annual energy savings of 9,954 kWh of energy,[7] amounting to
- Modelled annual carbon emissions reductions of 1,743 kgCO2e, and

[5] The WHR programme set a programme requirement that projects had to aim to retrofit at least 75 properties, with Energiesprong Sutton setting a target of 100, and Destination Zero 1 setting a target of 180 properties in their applications for funding.

[6] Q23. To what extent do you agree or disagree with the following statements in relation to the energy-efficiency work that has been installed in your property? Base: all respondents answering with work completed. My property is more comfortable to live in (n=150), My home is a nicer place to live (n=151), It has had a positive impact on my mental health (n=149)

[7] Energy modelling used data provided by project teams in their reporting to DESNZ, or where this was not available or considered poor quality, data on starting EPCs and measures installed was sourced through other management information or publicly available sources, or assumed based upon understanding of typical EPCs and baseline insulation, heating and space-heating requirements for the property archetypes treated.

- Modelled annual energy bill savings of £1,271.[8]

This equates to estimated total annual bill savings of £1.54 million, total annual energy savings of 12 GWh and an annual carbon emission reduction of 2,109 tonnes CO2e across both schemes.

Variation in energy, carbon and bill savings by measure type: Properties which had either a gas boiler or electric heating replaced with a heat pump achieved much higher energy savings than those properties that did not, although, generally, the more measures that were installed, the better the savings achieved. Specifically:

- Properties with a heating system upgrade were consistently modelled as achieving energy savings of 10 000 – 25 000 kWh, 1.5 – 5 tonnes CO2e and £1000 - £3500 in energy bill savings per year.
- Properties where the heating system remained unchanged generally saw lower energy savings in the range of 2000 – 15000 kWh, 0.3 – 1.5 tonnes of CO2e and £300 - £1500 off their annual energy bills.

The model found that properties which had the lowest energy performance certificate ratings prior to the retrofit achieved the greatest improvements in energy efficiency and building performance. Amongst properties which achieved EPC rating A, the majority (63 out of 78) had had solar panels installed, which can significantly improve an EPC rating due to the significant offsetting of electricity consumption from the grid.

The measure packages which generated estimated space and water heating savings greater than 85% all included heat pumps. Only properties with both heat pumps and PV installations were estimated to reach savings greater than 90%. EWI was installed by all projects, in 74% of all properties retrofitted, and thus no pattern could be observed in studying how effective it is in combination with other measures.

Energy behaviours: Residents' consumption behaviours in the home post-retrofit were typically driven by whether residents felt informed about their new measures and to what extent the works changed existing energy use habits. Confidence in using new measures tended to be positively influenced by receiving clear information and a demonstration or explanation for how measures worked. Participants were not always clear on how to change settings where there were new systems, particularly with more complex measures:

> *"You need to be a rocket scientist to understand it…it is unbelievably overwhelming." – Resident, commenting on the guidance to use an installed heat pump (Interview)*

Market outcomes: Evidence from interviews with a variety of stakeholders involved in delivery and analysis of secondary data suggests that the SHDF(D) and WHR programmes had some

[8] The modelled annual energy bill savings do not take into account increases in the price of energy during the programmes' implementation. The cost and carbon factors are only valid for the publication year (2023) and will change in the future.

positive impacts on the growth of retrofit businesses / sector. The programmes contributed to improved resilience within the retrofit market by increasing the employability for future retrofit projects for the companies involved. The companies participating in the programmes considered that they had developed their staff's technical skills in the delivery of whole house retrofit and retrofit more broadly. This was particularly driven, in SHDF(D), by the requirement for participating projects and their contractors to retrofit properties to the PAS2035/2030 standard. However, the programmes did not lead to significant maturation of the whole house retrofit supply chain nor the maturing of innovative materials.

Participating companies interviewed also reported that they struggled to deliver projects profitably. Despite this, they reported that the experience gained outweighed any loss of profit, and that the retrofit market was growing. Market growth, in this case, was considered to be driven predominantly by the subsequent waves of SHDF rather than the SHDF(D) and WHR programmes.

Analysis of project reporting and interviews with 96 project team members (including project leads) indicates that the programmes contributed to a modest increase in green jobs amongst the companies participating in delivery for the programmes. Owing to the timeframes for which the data were available, it was not possible to determine whether those jobs might be sustained in the long-term.

Cost reduction: WHR and SHDF(D) projects did not, overall, achieve the cost reductions intended. Issues driven by wider macroeconomic situation (including inflationary pressures on material and labour costs) meant that costs largely increased compared to baseline estimates. Projects undertook different strategies to reduce cost increases. In many cases, the depth of the retrofit was reduced by reducing the number of measures, or in some cases reducing the number of properties being retrofitted. In other cases, cheaper materials were used to bring down costs either by changing materials (e.g. brick slips vs brick effect render), or more expensive material aspects were removed (e.g. aluminium sills for the windows).

Value for Money: Outcomes have been more expensive to achieve than initially estimated. The evaluation was not able to establish quantitative measures of the additional effects of the programmes in each outcome area (i.e. the proportion of change that would not have been achieved in the absence of the programmes). However, the programmes have achieved most of the outcomes that were set out in the Theories of Change (ToC), and the programmes have been designed and delivered in an equitable manner.

Learnings: As innovation and demonstrator programmes, WHR and SHDF(D) aimed to generate learning for both social housing landlords and policymakers on whether and how whole house retrofit could be applied at scale to a reasonable cost. This evaluation has found that the programmes were successful in generating significant amounts of learning about the challenges of whole retrofit at scale, strategies that can be taken to mitigate these challenges and any negative effects they may have, and several good or effective practices for delivery. However, due to various internal and external factors distorting the extent to which project strategies for reducing costs could be realised, the programmes have not been able to

effectively answer the question of how to deliver whole house retrofit to scale at a reduced cost. The extent to which learning from the programmes and projects has been successfully and systematically applied to ongoing and future retrofits by social housing landlords and to ongoing and future policy, will be assessed in the ongoing evaluation of the SHDF Main Fund.

1. Introduction

The Department for Energy Security and Net Zero (DESNZ, formerly the Department for Business, Energy and Industrial Strategy (BEIS)) commissioned a joint process, outcome and economic evaluation of the Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund (Demonstrator) (SHDF(D)) programmes to run from February 2021 to August 2023. The two programmes have been evaluated jointly as they share similar aims, with SHDF(D) being launched as a scale-up of WHR.

This report covers the outcome and economic evaluation. Due to the small size of the programmes, particularly WHR, findings discussed in the report are common to both programmes; where findings are unique to one of the programmes, this is made explicit. The report builds upon, and complements, findings described in the process evaluation report (published June 2023).[9] It assesses whether outcomes, including lessons learned, have been achieved from the implementation of WHR and SHDF(D) and how specific retrofit approaches and contexts affect different outcomes.

Learnings generated from implementation of the programmes were anticipated to feed into the design and implementation of the ongoing SHDF programme in particular. Therefore, this report aims to provide policymakers and retrofit project teams with a greater understanding of the potential impact of such programmes. However, whilst both the WHR and SHDF(D) programmes required a deep approach to retrofit (reducing the property space heating demand through the implementation of multiple energy efficiency measures), with a challenging space heating demand target of 50kwh/m2/year, the SHDF Main Fund has a greater focus on delivery at scale of retrofit within a given grant funding amount, supported through design features such as less challenging performance requirements and the introduction of cost caps. The findings of this report are therefore specific to the deployment of deep retrofit approaches taken in SHDF(D) and WHR.

The research covers the programmes' inception, delivery, and project closure activities over the period February 2021 to 30 June 2023.[10]

The evaluation covers 13 evaluation questions, which are signposted at the beginning of each relevant chapter. The evaluation questions (EQs) explore the extent to which the following programme outcomes were achieved: improved building performance, resident outcomes, market outcomes, learning outcomes, and value for money to DESNZ. These outcomes, how they fit in the programmes' Theories of Change (ToCs) and how the EQs link to them is

[9] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

[10] Analysis for this evaluation utilised data up to and including 30 June 2023. At the time of writing, delivery and closure activities were ongoing for the two WHR projects. Meanwhile, SHDF(D) officially closed in December 2022, with DESNZ retaining oversight of delivery for the remaining properties to ensure grant conditions are honoured and outstanding commitments to residents are met. As of 30 June 2023, retrofit delivery was ongoing for five SHDF(D) projects.

illustrated in Figures 1 and 2 (Chapter 3). For each outcome, this report presents how the programmes intended to achieve the outcome; whether or not the anticipated change took place; and whether or not the programmes contributed to the outcome.

The remainder of the report is structured as follows:

- Chapter 2 provides an overview of and an introduction to the programmes.
- Chapter 3 summarises the methodology underpinning the evaluation.
- Chapter 4 describes the reach of the programmes in terms of the profile of the buildings retrofitted, the measures installed, and the residents benefitting.
- Chapter 5 presents the results of the evaluation of building energy performance including quality.
- Chapter 6 describes other benefits and disbenefits of the retrofits, as experienced and perceived by residents.
- Chapter 7 describes the evaluation's findings on programme job and market outcomes.
- Chapter 8 describes the extent to which projects were able to reduce costs compared to the counterfactual.
- Chapter 9 discusses whether anticipated learnings for government and social housing landlords were generated and applied to ongoing policy and project activity.
- Chapter 10 discusses the value for money of the programmes.

The report is also accompanied by a Technical Annex setting out the detailed methodology for the evaluation.

2. Overview of the programmes

Chapter 2 at a glance

The WHR and SHDF(D) programmes were launched in 2019 and 2021, respectively.

They awarded funding to four WHR (later two) and 20 SHDF(D) (later 14) projects. These aimed to: increase the energy efficiency of retrofitted homes, strengthen the supply chain, deliver to a high quality of retrofit, and report sources of cost reduction in whole house retrofit through at scale delivery and innovation.

2.1 Programme summaries

Both the WHR and SHDF(D) programmes tested the deployment of deep retrofit through a whole house approach: a holistic approach to retrofit that reduces the space heating demand through the implementation of multiple energy efficient measures and considerations of the whole house. This could include the implementation of insulation measures, heating system upgrades (such as heat pumps) and renewable energy generation (such as solar photovoltaics (PV)). The whole house retrofit approach aimed to maximise the improvement in the property's energy efficiency, to maximise comfort by eliminating issues such as damp and mould, and to limit disruption through coordinating the installation.

2.1.1 Whole House Retrofit (WHR)

WHR was designed as part of BEIS (now DESNZ)' Energy Innovation Programme with the purpose of testing whether whole house retrofit could be deployed at scale and, through a combination of economies of scale and innovative methods, halve the cost per house of renovating buildings to a similar to new build standard (in terms of quality and safety). It was designed on the basis of learnings from the 2014 UK Research and Innovation Programme 'Retrofit for the Future' and was intended to generate understanding for DESNZ that could be used in the rollout of future programmes. It also aimed to increase industry confidence in the affordability and value for money of deep retrofit when rolled out at scale, and industry's capacity to implement it.

WHR initially included four projects, with one withdrawing before work commenced and one dropping out after commencement of works. The two projects which successfully retrofitted houses, Nottingham City Council's Destination Zero I project and Energiesprong Sutton, were initially expected to complete work by April 2021, but the original 18-month timeline was extended to April 2023, primarily to account for COVID-19 and lockdown related delays, as well as inefficiencies in procurement and other project-specific delivery challenges. At the time of writing (June 2023), Energiesprong Sutton is still live (though in its final stage), while Nottingham City Council's Destination Zero I has concluded. In total, out of the original 470

properties that were initially planned to receive retrofits within the WHR programme a total of 74 properties are due to be completed by programme closure.

2.1.2 Social Housing Decarbonisation Fund (Demonstrator) (SHDF(D))

SHDF(D) launched at the end of September 2020 as part of the Government's Green Economic Stimulus Package of energy efficiency schemes announced in the July 2020 Summer Economic Update. It used the same delivery partner as WHR, Ricardo PLC, and built on WHR's design and programme management systems. However, SHDF(D) was larger in scale, had shorter delivery windows, targeted social housing by design and carried additional ambitions to stimulate the retrofit market and local authority capability and capacity to do retrofits, as part of the UK's economic recovery from the COVID-19 pandemic. It also aimed to provide learnings that could be used in developing the future waves of the SHDF programme.

There was a clear evolution in design from WHR to SHDF(D), with the latter taking on board numerous lessons learned from the former. The SHDF(D) team reduced the programme's energy performance and cost reduction targets (compared to WHR) but introduced the requirement to retrofit according to a prescribed process – the British Standards Institute's publicly available specification for domestic retrofit (PAS2035/2030). This specification was published but not yet mandatory across government energy efficiency schemes at the time of the WHR launch. Mandatory PAS2035/2030 compliance was intended to support consistency and quality of retrofit across SHDF(D) projects.

SHDF(D) awarded funding to 20 projects,[11] with different ambitions, innovations to be developed and applied, housing stock targeted, and type of residents. One project withdrew before funding was awarded; a further five projects dropped out during delivery. The formal closure of SHDF(D) projects was initially planned to be December 2021, but was extended to December 2022 with some residual delivery ongoing in five projects at the time of writing (June 2023).[12]

SHDF(D) had greater success than WHR in supporting projects to meet their target number of retrofits (as described in chapter 4). However, almost all SHDF(D) projects had to lower their original ambitions in terms of building performance targets, cost reduction goals, and clean heat technologies in order to deliver in the challenging market conditions and timelines for spending of grant money. Moreover, out of the 2,369 properties that were initially planned to receive retrofits within this scheme, a total of 1,143 retrofits were completed by August 2023, with a further 133 set to complete.[13] Table 1 below outlines the key information about the two programmes.

[11] 20 projects were successful at competition; however, one project (Renfrewshire' EnerPHit at Scale – Achray drive) did not accept funding.
[12] SHDF(D) officially closed in December 2022, with DESNZ retaining oversight of delivery for the remaining properties to ensure grant conditions were honoured and outstanding commitments to residents were met.
[13] Numbers from project reporting on completions and in-progress retrofits have been updated to the latest available data (August 2023). For consistency at the time of analysis, the report otherwise reports on the total

Table 1: Overview of WHR and SHDF(D)

Characteristic	WHR	SHDF(D)
Funding allocated (including for withdrawn projects)	£7.7m	£62m
Total final DESNZ expenditure	£3.1m	£39.8m
Total final expenditure (DESNZ + match funding)	£7.3m	£85.6m
Tenure type targeted	Any (though only social housing projects were selected for funding)	Social housing only[14]
Space heating performance target	15-30 kWh/m2/yr	50 kWh/m2/yr
Install cost-reduction target	5-15%	5-30%
Total projects	2 (originally 4)	14 (originally 20)
Initial target number of properties	396 (470 including properties from the 1 dropped out and 1 withdrawn projects)	1,738 (2,369 including 5 dropped out and 1 withdrawn project)
Final target number of properties (August 22023)	74	1,276
Completed properties (August 2023)	64 (10 still to complete)	1,143 (133 still to complete)
Initial programme timeframes	June 2019 – March 2021 (1.5 years)	September 2020 – December 2021 (1 year)

number of properties (completed and still to complete retrofits) as of April 2023. As of April 2023, the final target number of (SHDF(D)) retrofits was 1,293 properties and 20 communal spaces (SHDF(D)), with 1,143 completed and 180 still to complete.

[14] As per Competition Guidance for the SHDF(D) programme: "The focus must be on social housing. Where leaseholder or freeholder (right to buy) properties are included grant and match funding must be used on those properties, without costs being passed on to leaseholders/freeholders."

Characteristic	WHR	SHDF(D)
Final programme timeframes	June 2019 – March 2023 (3.5 years) with residual delivery ongoing at the time of writing	September 2020 – December 2022 (2.3 years) with residual delivery ongoing at the time of writing

Source: DESNZ reporting at the time of writing (June to August 2023). The final target number of properties, completed properties and properties still to complete have been updated to the latest available data (August 2023). For consistency at the time of analysis, the report otherwise reports on the total number of properties (completed and still to complete retrofits) as of April 2023. As of April 2023, the final target number of (SHDF(D)) retrofits was 1,293 properties and 20 communal spaces, with 1,143 completed and 180 still to complete. There is no change between April and August data for WHR.

2.2 The causal hypotheses being tested

The evaluation took a theory-based approach, which meant that the intended outcomes of the programmes (as set out in the programme ToCs) were measured by gathering evidence to test the plausibility of the causal hypotheses linked to each outcome.

The WHR and SHDF(D) ToCs are presented in Figures 1 and 2 of chapter 3. Whilst they have slight differences in terms of policy context and objectives, they have most intended outcomes in common. These outcomes can be formulated as the following causal hypotheses:

- WHR and SHDF(D) funding supports:
    - Improvements to building fabric of properties receiving retrofits and
    - (In some cases) the installation of low-carbon heating measures, combined with
    - The remedy of issues in the home affecting energy use (e.g. damp, mould, and draughts),
    - To a high degree of quality and finish.

  Through these improvements to building performance, the energy efficiency of the home is improved. Improved energy efficiency contributes to energy bill savings and carbon emissions reductions. These outcomes are more likely to occur where residents receive handover guidance on how to use the home to enhance energy efficiency post-retrofit.
- WHR and SHDF(D) require retrofit to a high quality standard, as well as close engagement of residents to support resident satisfaction and buy in. Projects respond to these requirements positively and retrofit properties to a high quality and high degree of satisfaction. Residents benefit from the retrofit, including having homes that are healthier, more aesthetically pleasing, and cheaper to heat.
- Participation in WHR and SHDF(D) supports jobs because social housing landlords and installers need to employ people in green jobs to deliver the works to a sufficient standard.

- The requirements of the schemes influence skills development, which increases suppliers' capability and financial confidence, leading to maturation and growth of the retrofit supply chain.
- By participating in WHR and SHDF(D), social housing landlords generate delivery lessons, systems and infrastructure that gives them the capability and confidence to retrofit at scale and at a reduced cost.
- By delivering WHR and SHDF(D), DESNZ generates knowledge that informs other retrofit programmes, reducing costs and increasing effectiveness and efficiency.

3. Outcome and economic evaluation methodology

Chapter 3 at a glance

The evaluation uses a mixed methods approach to outcome evaluation and a qualitative approach to evaluating value for money.

It draws on different evaluation techniques for each outcome evaluated, including energy savings modelling, contribution analysis, and qualitative comparative analysis.

It utilises secondary and primary data including: monitoring data, management information, grey literature, interviews with project and programme delivery teams, residents, and the wider supply chain, a resident survey and a video ethnography.

This outcome evaluation has been able to draw upon a rich evidence base derived from multiple sources. However, the evaluation is subject to several gaps in evidence which has reduced the comparability of findings between projects and the ability to conduct quantitative analysis and modelling in the most robust way. The short (or non-existent) time period between the closure of some projects and data collection for this evaluation has also meant that, for some projects, it was not possible to collect data on actual outcomes / change.

3.1 Outcome and economic evaluation

3.1.1 Overarching approach

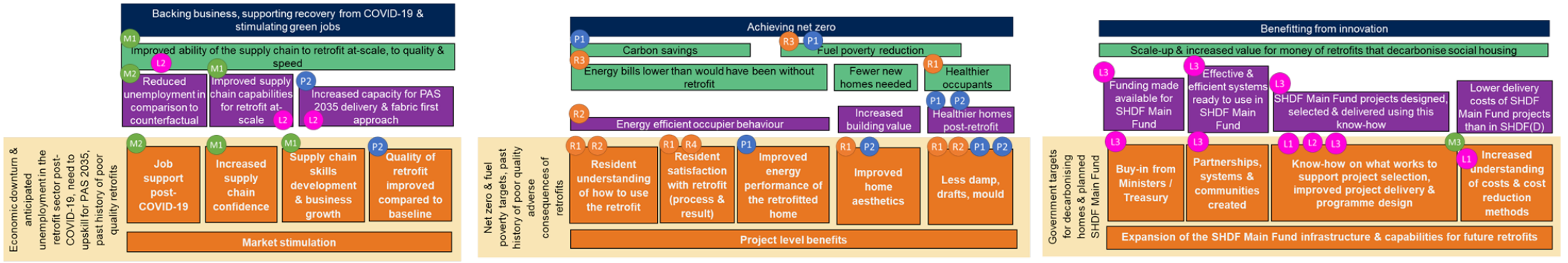
The evaluation took a theory-based approach to outcome and economic evaluation, drawing on mixed methods research. Our overall analytical approach took the following five steps:

Step 1: Development and refinement of the ToCs. ToCs existed for WHR and SHDF(D) prior to the start of the evaluation. At the outset of the evaluation, the evaluation team ran a workshop with DESNZ to probe on key components (assumptions, expected outcomes) of the ToC – this information fed into the development of the overarching Evaluation Plan (produced April 2021). Based upon evidence collected through the process evaluation, the evaluation team updated and refined the ToC diagrams and validated these with DESNZ. These updated ToCs were published in the process evaluation report (see Figures 1 and 2).

Step 2: Refinement of the evaluation questions and research themes. Outcome evaluation questions were developed which enabled the assessment of outcome pathways established in the updated ToCs. The questions were developed into frameworks for research, that set out

the additional assumptions to be tested, lines of inquiry and data collection methods. On this basis research tools were also developed.

Figure 1: The outcome evaluation questions for SHDF(D) and how these enable the testing of the TOC



Theme	Icon	Main evaluation question
Resident outcomes	R1	Are occupants satisfied with the retrofits?
	R2	How has tenant behaviour changed post-retrofit?
	R3	Are tenants paying less on their energy bills post-retrofit?
	R4	Have projects affected non-participating residents, and if so, how?
Performance outcomes	P1	How much have whole house retrofits improved energy performance and why?
	P2	What level of PAS 2035-compliance and build quality was achieved and why?
Market outcomes	M1	Have the programmes contributed to retrofit market growth?
	M2	To what extent have the programmes supported green jobs?
	M3	Have cost reductions for retrofit been achieved and why?
Learning outcomes	L1	Which delivery models have been most successful? (QCA)
	L2	How much have the schemes helped develop landlord capability for delivering future retrofit?
	L3	How much have the schemes helped BEIS develop their policy portfolio for retrofit? / How much have the schemes helped expand government capability to support social housing decarbonisation?

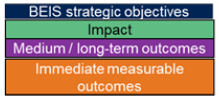
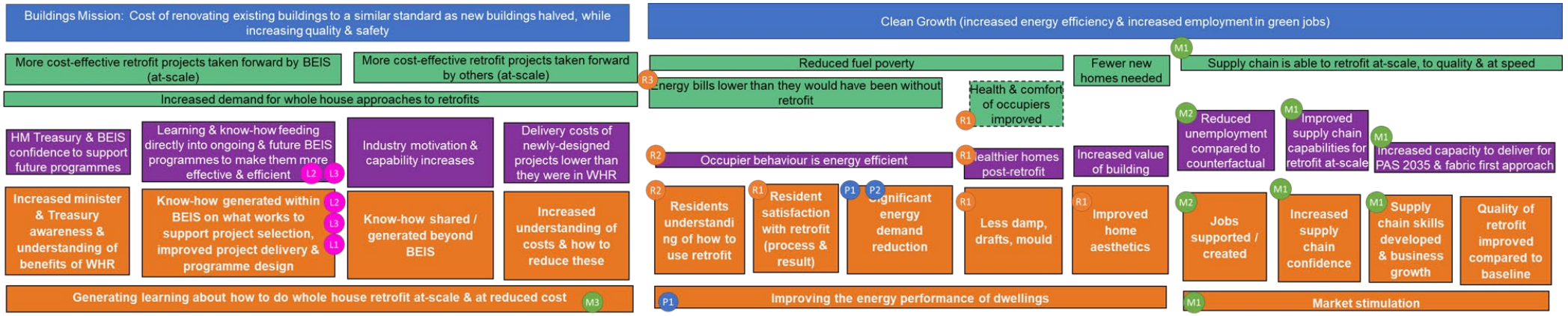


Figure 2: The outcome evaluation question for WHR and how these enable the testing of the ToC



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	L2	How much have the schemes helped develop landlord capability for delivering future retrofit?
	L3	How much have the schemes helped BEIS develop their policy portfolio for retrofit? / How much have the schemes helped expand government capability to support social housing decarbonisation?

Step 3: Data collection. Evidence was collected to support / refute the hypotheses through interviews, survey and video work and collated and cleaned monitoring data (final and interim project reports), thermal efficiency and cost data.

Step 4: Data analysis and hypothesis testing. Different analytical techniques were employed to draw conclusions on programme impact, as set out below. These analytical techniques were selected depending on what was the most appropriate for the nature of and the data available to assess each outcome area. These different techniques enabled us to test and draw conclusions on the validity of the different causal assumptions.

Step 5: Development of findings and conclusions. As a final step, the findings per stand were synthesised into a single narrative of performance and outcomes relative to the ToC. To do this, an internal analysis meeting was held with the fieldwork leads to discuss salient and interesting emerging findings. The evaluation team then held a further analytical meeting once the main stage of analytical activity had finished to discuss findings for each outcome area and plan our narrative.

The evaluation has assessed whether outcomes were achieved but has not investigated the final impacts of the programme. This is due to the timing of the evaluation which coincides with the recent closure of the projects, with some projects ongoing. It is therefore not yet possible to measure impacts, which occur in the longer term. This limitation particularly affects impacts on energy, carbon and bill savings, jobs, and resident outcomes such as ongoing well-being and energy use behaviour.

3.1.2 Assessing the additionality of the programmes

As discussed below in section 3.3, there was no counterfactual constructed for the outcome evaluation. This has significantly limited the extent to which the additionality of the programmes could be assessed.

Within the process evaluation, additionality was considered through the following:

- How do/did LAs otherwise implement whole house retrofit in the absence of the programme.

As reported in the process evaluation report,[15] in interviews for this outcome evaluation, and in project reporting, project teams reported that they would have been unlikely to have implemented the projects at all, or to the same scale and profile, without the funding. Several projects used the funding to treat particularly hard-to-treat homes, some of which might have otherwise been demolished, and other projects used the funding to develop blueprints for ongoing deep retrofit across other parts of their housing stock. The analysis of additionality for the process evaluation was, however, highly dependent on self-reporting by participating local

[15] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

authorities. It was not possible, on the data available, to map retrofit activity amongst non-participating local authorities and this is a key limitation of the analysis.

For the outcome evaluation, additionality was also considered in terms of:

- Whether properties retrofitted met the eligibility criteria of the programmes (in terms of having an EPC lower than C and being – overall – hard to treat).
- Whether residents benefitting from the retrofits (e.g. those experiencing increased warmth, comfort or satisfaction) would have anyway experienced similar benefits from no intervention.
- Whether companies benefitting from the retrofits (e.g. those improvements in skills and the reputation of their company) would have anyway experienced similar benefits from no intervention.

In terms of the properties retrofitted, chapters 4 and 5 describe how, in most cases, the properties retrofitted had low EPC ratings and in several cases were particularly hard-to-treat. However, section 5.2 also describes that a small proportion of properties retrofitted had starting EPC ratings of C and (in two cases) B, which was higher than the pre-retrofit EPC rating required by the programmes (of below C). According to DESNZ, such properties were included where it was not practical to exclude the properties due to their location and proximity to other properties being retrofitted. However, in the case of at least one project this means that close to 50% of the retrofitted properties were already performing efficiently (according to their EPC rating).[16]

In relation to resident outcomes, this evaluation report has explored residents' perspectives and experiences, taking into consideration the specifics of the type of retrofit they had and their experience of the retrofit delivery (i.e. what factors might have positively or negatively skewed their experience and final opinions?). The evaluation has also systematically assessed evidence from the resident research against the programme ToCs (see Figures 1 and 2 in chapter 3) to assess where the evidence supports or refutes the causal theories and therefore where the evidence for additionality is strong or weak. However, overall, the analysis of outcomes of the retrofits for residents has been limited by the fact that retrofits, in many cases, had only recently or had not yet completed. As a result, it was not yet certain what the outcomes were in order to understand whether they would have occurred anyway without the programmes.

For the analysis of market outcomes, the evaluation systematically assessed alternative explanations through a contribution analysis methodology. As set out in chapter 7, the evaluation concludes that SHDF(D) and WHR were additional in the effects they produced for participating companies due to the novelty of the whole house approach for most of those participating, and the targeted scale of the programmes.

[16] 14 properties retrofitted through the WHR Energiesprong Sutton project had a starting EPC rating of band C or above (representing 61% of their projects retrofitted).

3.1.3 The analytical approaches for assessing each outcome

The evaluation applied a range of qualitative and quantitative evaluation approaches to test the outcome pathways established in the programmes' ToCs, as summarised here. Further detail on these approaches can be found in the Technical Annex.

- For the analysis of programme reach in chapter 4, the evaluation team reviewed data from project final reporting on (a) the baseline profile of the retrofitted properties and the measures installed; and (b) the demographic profile of the benefiting residents as collected through the survey of residents. For the reported data on properties treated, some data gaps had to be filled using proxy data combined with assumptions.
- For the analysis of building performance outcomes in chapter 5, the evaluation team modelled energy, carbon emissions reductions and bill savings using information on the properties retrofitted and measures installed, combined with externally sourced information on the anticipated energy saved through different measures. The findings from the modelling were further triangulated with changes to EPC ratings reported by projects,[17] and evidence of changes in home warmth, comfort and energy bills as reported (perceived) by residents, and evidence from analysis of the implementation of PAS2035/2030, included in the process evaluation.[18]
- For the analysis of other resident benefits in chapter 6, findings from four strands of research that have involved residents were synthesised (qualitative depths, online survey, AppLife mobile diary, site visits).
- For the analysis of jobs and market growth in chapter 7, a contribution analysis approach was applied to a range of evidence sources, but primarily the findings of interviews with project teams.
- For the analysis of cost reduction outcomes in chapter 8, a framework of actual, proxy, benchmarked and estimated baseline and endline retrofit costs was developed and these were compared to assess whether costs were reduced. This was cross-referenced with qualitative evidence of the achievement / non-achievement of cost reductions and conducted a qualitative comparative analysis (QCA) to draw overall conclusions.
- For the analysis of learning outcomes and whether / how these were achieved in chapter 9, evidence was drawn from interviews with DESNZ and project teams; and undertook a QCA drawing on project reporting.
- To assess value for money, as presented in chapter 10, a qualitative approach was taken following the National Audit Office (NAO) approach of economy, efficiency,

[17] EPC ratings per property were taken either directly from project reporting or, where projects did not report this, the evaluation team looked this up from postcode data from reporting.
[18] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

effectiveness and equity ('4E') of the interventions, triangulating data collection from the rest of the evaluation with costs data.

3.2 Data collection

The outcome and economic evaluation has drawn upon two waves of secondary and primary data collection and analysis. The methodology (including limitations) for the data collected for the process evaluation is covered in full in the Technical Annex to the process evaluation[19]. The methodology (including limitations) for the data collected for this outcome and economic evaluation is covered in full in the accompanying Technical Annex to this report. A summary of these limitations is provided in section 3.3.

3.2.1 Process evaluation data collection (March 2021 to July 2022)

- Programme and project data:
    - Grant applications and assessments
    - Programme Management Information (MI)
    - Project Reporting/Delivery Data.
- Literature: A full bibliography of literature reviewed was included in the appendix to the process evaluation report.
- Qualitative depth interviews with:[20]
    - DESNZ delivery team and representatives of the Scheme Administrator Scoping interviews (six scoping interviews, and seven follow-up interviews)
    - Project leads and other project team members (23)
    - Resident Liaison Officers (seven)
    - Withdrawn projects and unsuccessful bidders (four)
    - Manufacturers and experts (15)
    - Whole House Retrofit industry representatives (11)
    - PAS2035/2030 Practitioners (10).
- Seven project-level case studies.
- Five site visits undertaken during the installation phase through which sites and retrofitting activity were observed and insights were collected from project teams, partners, installers, contractors and residents.

[19] Joint Process Evaluation Report – Technical Annex - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.
[20] Number in parentheses represents the of interviews conducted. Several of the interviews were conducted with a group of individuals.

- Shadowing of six programme meetings
- A ToC workshop with the DESNZ delivery team (April 2021).
- A workshop with Monitoring Officers to collect their views on project-level process achievements and challenges (July 2022).

3.2.2 Outcome evaluation data collection (November 2022 to April 2023)

- Programme and project documentation.
- Publicly available data on companies via Companies House.
- Qualitative depth interviews with:[21]
    - Participating residents (56 in total – covering 10 local authorities)
    - Project leads (33)
    - Project team members (e.g. architects, construction companies) (63)
    - DESNZ delivery and policy team members (12).
- A mobile diary task (AppLife) of 10 participants showing new measures installed, operational knowledge of such measures, and quality of the works.
- Online survey of participating residents, with a total of 256 respondents from two WHR projects and 14 SHDF(D) projects.

Further detail on the sampling strategy and methodology employed for data collection, as well as considerations on bias, can be found in Technical Annex 2.

3.3 Methodological limitations

A more detailed consideration of the limitations for each individual workstream forms part of the respective methodology discussions in the Technical Annex. The key limitations are also summarised below:

- **There is no counterfactual case**: It was not possible to identify or construct a counterfactual beneficiary group against which to compare how participants in the programmes changed in each of the outcome areas, within the data collection constraints and temporal and budgetary scope of this evaluation. The lack of counterfactual analysis does, however, reduce certainty around the extent to which the programmes caused the observed change. The perspectives of participating projects on this additionality of the programmes are summarised in section 3.1.2 above.
- **Coverage**: There are some projects for which there is less data available (through any of the data sources) than others - in particular, data relating to information on final expenditure (including matched funding), final measures installed and the baseline fabric and heating in retrofitted properties. In some cases this was because some

[21] Number in parentheses represents the of interviews conducted. Several of the interviews were conducted with a group of individuals.

projects had only recently closed or were still in progress when data was being collected and reported for the outcome evaluation. This has affected data availability and the extent to which conclusions on final outcomes can be drawn, particularly at a project level. As data gaps have tended to be most prevalent for the projects which progressed slower in their delivery, useful judgements, assumptions or exceptions could still be made, based upon management information and/or findings from interviews with DESNZ.

- **Resident survey**: The relatively small number of properties retrofitted within the SHDF(D) and WHR programmes, and correspondingly small sample of 1,335 residents meant that the overall survey base was relatively small (256 respondents). In particular, analysis by project was not possible as in most cases the sample size per project was below 30 cases, limiting the ability to draw any statistically significant differences. The survey data has not been weighted as this required a larger sample size, as well as a better understanding of the profile of the sample population.
- **Self-selection bias**: Participants with a particularly negative or positive experience of the programmes may have felt more inclined to participate in fieldwork than those with more neutral experiences. It is not possible to gauge to what extent self-selection bias is prevalent or not. The quantitative and qualitative research with residents is largely mutually reinforcing and aligns well with what would be expected given the status of projects and information on implementation challenges and successes set out in project reporting.
- **Temporal effects**: The timing at which the interviews were conducted is likely to have had an effect on interviewee's perspectives. This is particularly the case for the residents, as not all participants in the resident research had had their retrofits completed by the time of the interview (and both the evidence collected for this research and for other Ipsos evaluations for DESNZ[22] has shown that residents are more likely to talk positively about retrofits and installations if the works are complete).
- **Wider context effects**: The sharp increase in energy prices and the associated collapse of domestic energy providers that occurred in the winter of 2021-2022. This may have impacted consumer energy behaviours and their perspectives on energy consumption and therefore shaped the findings of the research with residents. This may also have impacted the findings from energy bill savings modelling, which used 2023 energy prices. When using 2021 energy prices, energy savings would be expected to be 55 to 82% lower.

[22] Evaluation of the Green Homes Grant Voucher Scheme (GHGV) - Interim Outcome and Economic Evaluation Report, BEIS Research Paper Series Number 2022/028

4. Reach of the programmes

This chapter describes the reach of the two programmes in terms of the projects supported, the properties retrofitted, the measures installed, and the households benefitting from the programmes.[23, 24]

Chapter 4 at a glance

Out of 24 projects which were initially selected across both programmes, 16 (14 SHDF(D) and two WHR) reached the implementation phase and closed with at least some properties retrofitted.

Only four out of the 14 SHDF(D) projects did not reduce the number of properties retrofitted (or to be retrofitted) compared to the number planned at application stage. Both projects for WHR failed to achieve the target number of retrofitted properties as outlined in their application, and therefore did not achieve retrofit 'at scale'.

Project monitoring data up to April 2023 demonstrated that under SHDF(D) there were a total of 5,182 measures either in place or scheduled for future installation across 1,293 properties and 20 communal spaces. Similarly, in WHR, 256 measures were either already installed or planned to be installed in 74 properties. Across both programmes, 180 property retrofits were ongoing at the time of writing (June 2023).

The most common type of property retrofitted were semi-detached or terraced houses, and mid-floor flats. Most properties were 20th century pre- and post-war semi-detached or terraced houses, on combi boiler heating systems with below EPC C ratings.

The most commonly installed measures were external wall insulation (EWI), loft insulation, doors and windows, heat pumps and solar photovoltaic (PV). A diversity of occupiers participated in the retrofit projects, motivated either by feeling compelled or by the desire to improve their homes' warmth and address existing issues.

4.1 Projects funded and properties reached

As of June 2023, of the 24 projects which were initially selected across both programmes, 16 reached the implementation phase and closed with at least some properties retrofitted. Out of

[23] There are gaps in the data and issues with the quality of some of the data used to draw with some in the information presented in this chapter. Ipsos and Energy Saving Trust made certain assumptions regarding property types, EPC rating changes, and property age in the dataset. As a result, these findings should be treated with caution.

[24] The figures presented throughout this chapter are based on the latest scheme data available at the time of analysis (April 2023). As of April 2023, the final target number of (SHDF(D)) retrofits was 1,293 properties and 20 communal spaces. The final target number of WHR retrofits was 74 retrofits.

the 20 SHDF(D) projects, five are in progress, nine have completed, five withdrew, and one dropped out prior to funding award. Out of the four WHR projects, one has completed, one is in its final phase, one withdrew mid-programme, and one dropped out at the start of the programme (and before any grant payments were made).[25] While SHDF(D) retrofitted properties across both England and Scotland, projects that were selected within WHR projects covered England only (the project which withdrew was based in Scotland). Both programmes were implemented across urban, suburban and rural areas. WHR was open to any type of property, but the successful bids mostly proposed to retrofit social housing.[26] SHDF(D) funding was only available for the retrofitting of social housing.

As of April 2023, the projects funded had had varying levels of success in retrofitting the number of properties initially anticipated in the project applications. Five projects[27] successfully retrofitted the number of properties originally anticipated. In the case of three projects,[28] the variation in properties reached was minimal. Four projects[29] reduced the scale of properties they reached by more than a third but less than 50%, and four projects[30] reduced the scale by 50% or more. No project achieved the target of retrofitting 200 properties, as originally set out for WHR, and therefore did not achieve retrofit ‘at scale’ as originally envisioned. Table 2 below shows the number of properties retrofitted (or being retrofitted) at project level. This is discussed further in chapter 10.

[25] 'Dropped out' refers to projects that did not accept grant funding and 'withdrawn' to projects that went through a formal withdrawal procedure.
[26] WHR received and approved a proposal which included some privately rented Duchy of Cornwall properties; however these were withdrawn right at the start of the project.
[27] Nottinghamshire Net Zero Carbon Housing Demonstrator; Orbit Housing Incremental Whole House Retrofit Scheme in Stratford; the Alva Community Regeneration through Decarbonisation project in Clackmannanshire; Warner Homes Argyll and Bute; and the SHDF(D) Leeds Whole House Retrofit Project.
[28] Gloucestershire SHARe and CaRe Demonstrator; the Retrofit of Electrically Heated Homes in Wychavon and Northampton’s Whole House Retrofit project.
[29] Social Housing Retrofit Accelerator Cornwall; Destination Zero II: The Next Step; the Clarion Housing Group advanced retrofit project in Fenland; and Manchester’s Xtra-Z project.
[30] Aberdeen’s project DORIC, the National Net Zero Retrofit Accelerator and both WHR projects.

Table 2: Number of properties retrofitted at project-level, as of April 2023[31]

Project	Number of properties retrofitted/to be retrofitted As of April 2023	Number of measures installed/to be installed As of April 2023
Nottinghamshire Net Zero Carbon Housing Demonstrator	25	87
Orbit Housing Incremental Whole House Retrofit Scheme	69	377
Social Housing Retrofit Accelerator Cornwall	40	160
Warmer Homes Argyll & Bute	130	515
Retrofit of Electrically Heated Homes	176	1021
Gloucestershire SHARe and CaRe Demonstrator	46	225
Destination Zero II: The Next Step	65	209
Project DORIC (Domestic Optimised Retrofit Innovation Concept)	50	286
Alva Community Regeneration through Decarbonisation – Weir Multicom Non Traditional House Upgrade – 2020-21	15	120
Clarion Housing Group Advanced Retrofit Project	116	367
Northampton Whole House Retrofit	149	350
Xtra-Z (cross-tenure retrofit achieving zero carbon)	90	463
National Net Zero Retrofit Accelerator	129	750
Leeds Whole House Retrofit	193	252

[31] This table draws on project data available at the time of analysis, April 2023 and cannot be considered final as some projects were still ongoing.

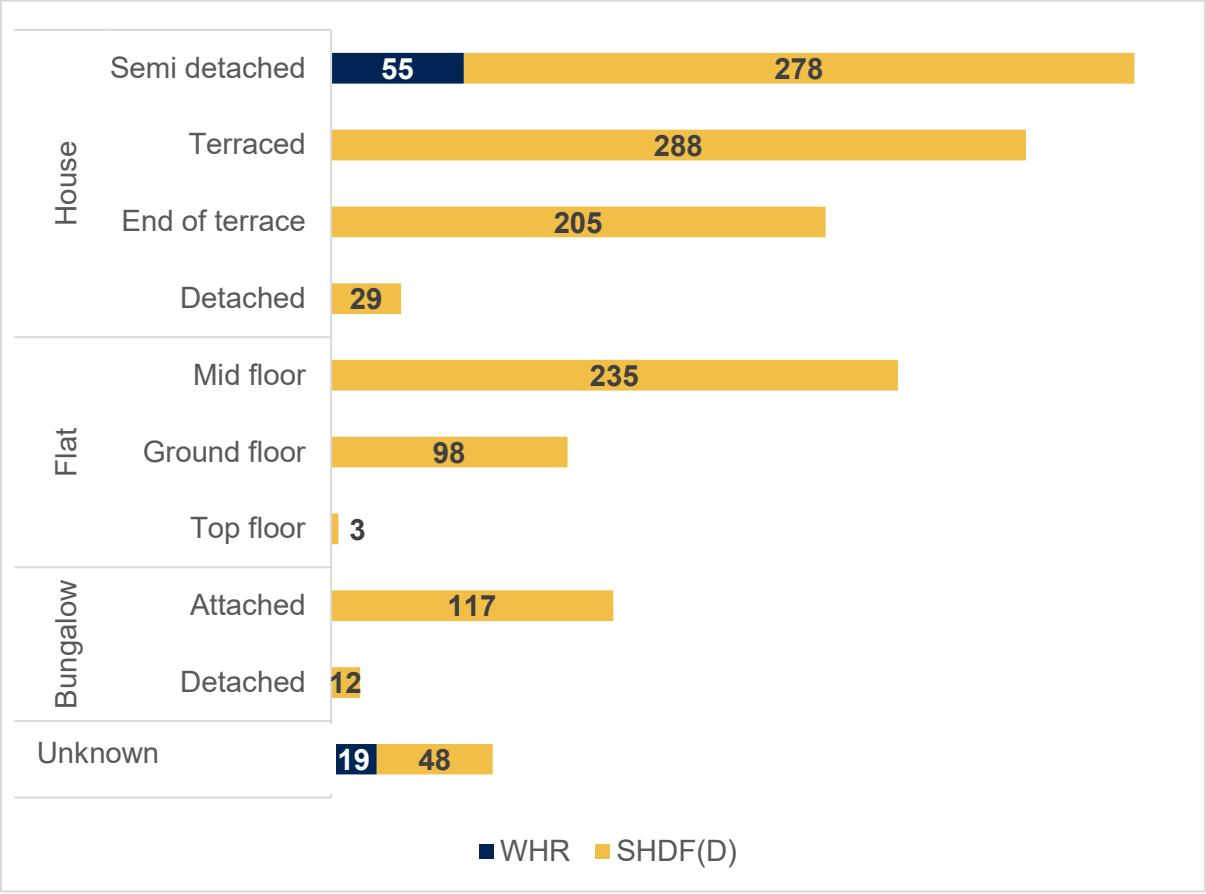
Project	Number of properties retrofitted/to be retrofitted As of April 2023	Number of measures installed/to be installed As of April 2023
Energiesprong Sutton	23	138
Destination Zero I	51	118
SHDF(D) total	**1,293**	**5,182**
WHR total	**74**	**256**
Combined total	**1,365**	**5,438**

4.2 The profile of retrofitted properties

4.2.1 Types of buildings

Figure 3 below provides a breakdown of the composition of properties retrofitted through the programmes by type of property. Among the three categories (houses, flats, bungalows), houses were the most commonly retrofitted, particularly terraced houses. Attached bungalows and mid-floor flats were also common, whilst detached bungalows and top-floor flats were less prevalent in project portfolios. The properties retrofitted through WHR (in blue) were all semi-detached houses, while the properties retrofitted through SHDF(D) (in orange) were more varied.

Figure 3: Types of properties retrofitted within WHR and SHDF(D) as of April 2023



Source: Measures data from project reporting. Base: 1387 consisting of 1293 properties and 20 communal spaces for SHDF(D) and 74 properties for WHR.

4.2.2 Building age and archetype information

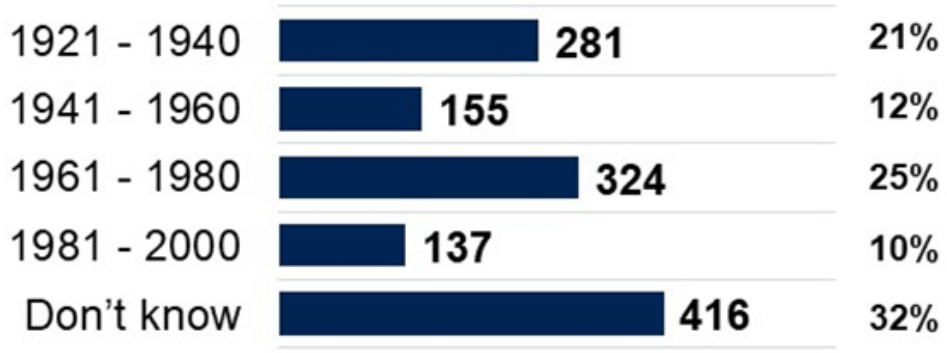
Within the WHR programme, the two projects retrofitted four archetypes: non-traditional construction and 'boxy' housing in Sutton; and solid brick 'interwar' properties (1918 – 1945)[32] and Victorian properties in Nottingham. From a building physics perspective, the 'boxy' housing

[32] No comprehensive data was available on the age of the properties retrofitted through WHR.

archetype in Sutton has the lowest heat loss and sufficient roof space for a good amount of solar PV.

As a larger programme, supporting more projects across a wider geography, SHDF(D) reached a wider variety of property archetypes, including solid brick wall and narrow cavity semi-detached and detached houses, three-storey apartment blocks, traditionally built houses, and 'no-fines' system-build housing stock. Most properties retrofitted with SHDF(D) funding were constructed during the interwar period (1921 to 1940) or between 1961 and 1980, though a third of the information on property age is missing from project data.

Figure 4: Age of properties retrofitted using SHDF(D) funding as of April 2023



Source: Project reporting. Base: 1293 properties and 20 communal spaces.

4.2.3 Pre-retrofit energy performance and heating systems

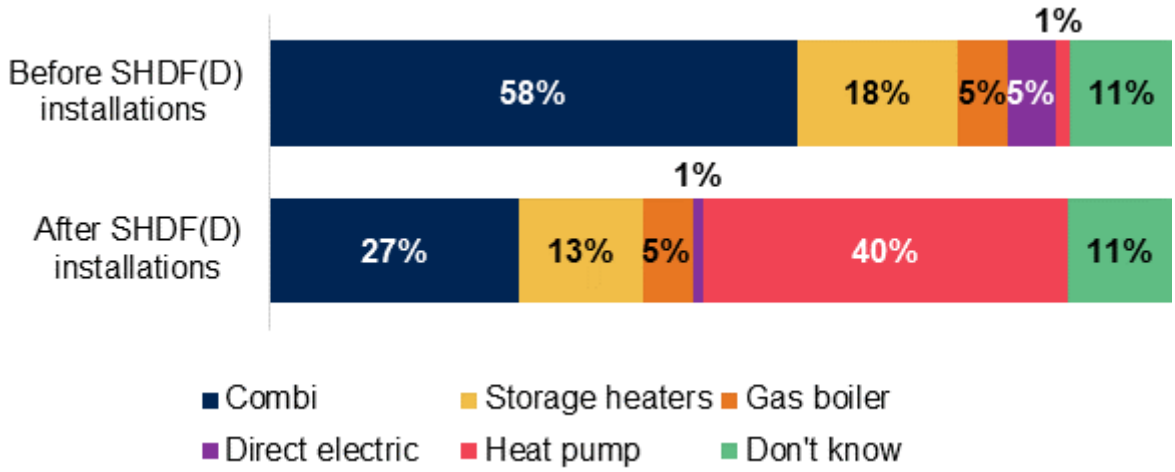
Analysis of pre- and post-retrofit energy performance is provided in the next chapter (chapter 5). Based on project reporting, 77% (n=57) of properties retrofitted with WHR funding had an 'Energy Performance Certificate' (EPC) rating of D or E prior to retrofit; only two WHR properties had a starting EPC rating of F. SHDF(D) properties also typically had a starting EPC of D or E (83%, n=1079), though 15% (n=199) had starting EPCs of C, F and G.[33]

All properties treated under the WHR scheme initially had a combi boiler. Out of these properties, 32% (24) had a heat pump installed as part of the retrofitting process. The remainder retained their existing heating system at the end of the retrofit.

In comparison, the SHDF(D) programme exhibited greater diversity in terms of heating systems. Figure 5 below illustrates the types of heating systems found in the properties retrofitted under the SHDF(D) scheme, both before and after the installations. The most substantial change observed was in heat pump prevalence amongst participating properties, which are now installed in 41% of the targeted properties. This shift led to a corresponding decrease in the prevalence of traditional heating systems, such as combi boilers, storage heaters, and electric heaters.

[33] Pre- and post- retrofit EPC ratings are discussed in more detail under Chapter 5.

Figure 5: Heating systems of SHDF(D) properties before and after installations, as of April 2023



Source: Project reporting – for SHDF(D) only. Base: 1293 properties and 20 communal spaces. The benchmarked data for retrofits not yet complete may affect the accuracy of the findings. The 11% information missing is from properties within the following projects: Wychavon Retrofit of Electrically Heated Homes, Warmer Homes Argyll and Bute, National Net Zero Retrofit Accelerator, and Destination Zero II.

4.2.4 The pre-retrofit condition of properties

Residents participating in survey and qualitative interview research for this evaluation were asked about the condition of their home before the retrofit works began. They reported on homes being poorly insulated and not retaining heat in the winter, which often led to having heating on for long periods of time. Residents also described inefficient heating systems (for example night storage heaters, which they could not control or customise to the right temperature) and issues with old/dilapidated doors, roofing, and windows. These issues led to problems in the home including: draughts, condensation, and leaks; mould, damp, and rot in windows; cold rooms or cold spots in the home.

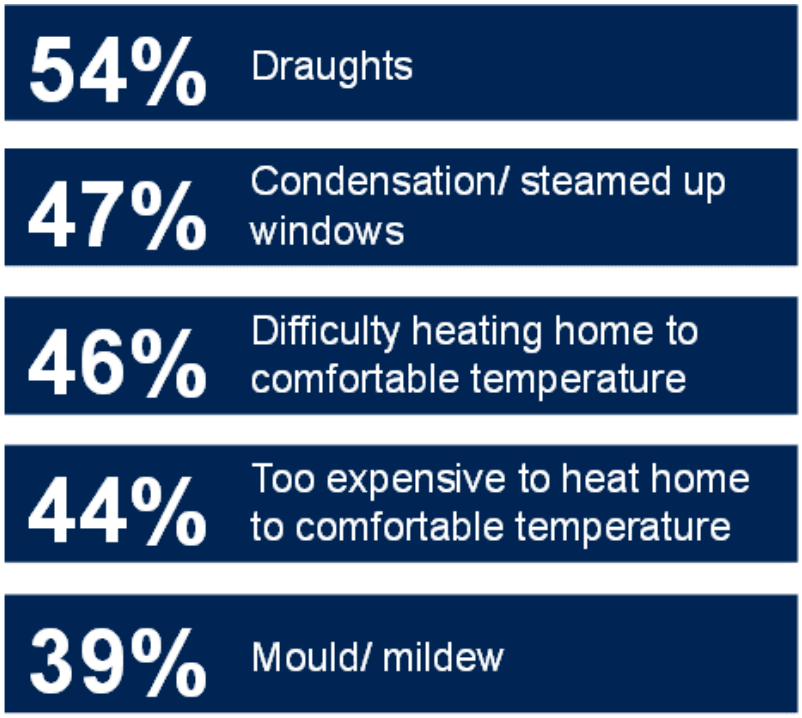
> *"I had damp and mould…outside and mould inside near the bedroom… If I didn't air the house, I got condensation…[I had] cold flooring… I was losing heat pretty fast [but] heat stays in a bit longer now [because of the] insulation."* – Resident (Interview)

Data from the resident survey showed that draughts were the most widely cited problem with homes prior to the retrofits (54%, n=136), followed by condensation (47%), heating the home to a comfortable temperature (46%) and the expense of heating the home to a comfortable temperature (44%).[34] Two-thirds of residents (67%, n=171) selected more than one response, suggesting the majority had experienced, or were experiencing (depending on when they were

[34] Q12. Before you had the energy-efficiency work, did you have any of these problems with your home? Base: all respondents answering (n=253)

surveyed)[35] multiple issues with the home. Over a quarter of residents surveyed (28%, n=73) stated they were experiencing issues with condensation as well as heating the home to a comfortable temperature prior to beginning the retrofit.

Figure 6: Most widely cited problems with homes before retrofits amongst residents



Source: Resident Survey. Base: All respondents answering (253). Q12: Before you had the energy-efficiency work, did you have any of these problems with your home? Select all that apply. The figure shows the five most popular responses from a multiple choice question.

4.3 Profile of measures

All projects supported through WHR and SHDF(D) were required to take a 'fabric first' approach to whole house retrofit, meaning that projects either only take steps to improve air tightness and insulation or do this before installing any new heating systems.[36] Fabric improvements typically involved roof insulation and EWI and, sometimes, underfloor insulation. Several projects installed mechanical ventilation with heat recovery (MVHR)[37] across all or some of their properties, whilst others introduced solar panels and heat pumps, heat controls and smart systems. Many projects also upgraded residents' windows and doors. Each property

[35] The resident survey was conducted in one wave in 2023. At the time of the survey some residents had had their retrofits completed and others still had retrofits ongoing. This question (Q12) was asked in relation to their situation pre-installation, as shown in the footnote above.
[36] Fabric first is a principle that states that heat demand should be reduced as far as possible by improving the building fabric and its construction before introducing new energy systems.
[37] Mechanical ventilation with heat recovery (MVHR) is a whole-house ventilation system that extracts damp air and draws in fresh air from outside.

received on average 4.5 measures, ranging from three to seven measures for WHR and from one to ten measures for SHDF(D), as shown in the figures below.

Figure 7: Numbers of measures installed in SHDF(D) properties, as of April 2023[38]

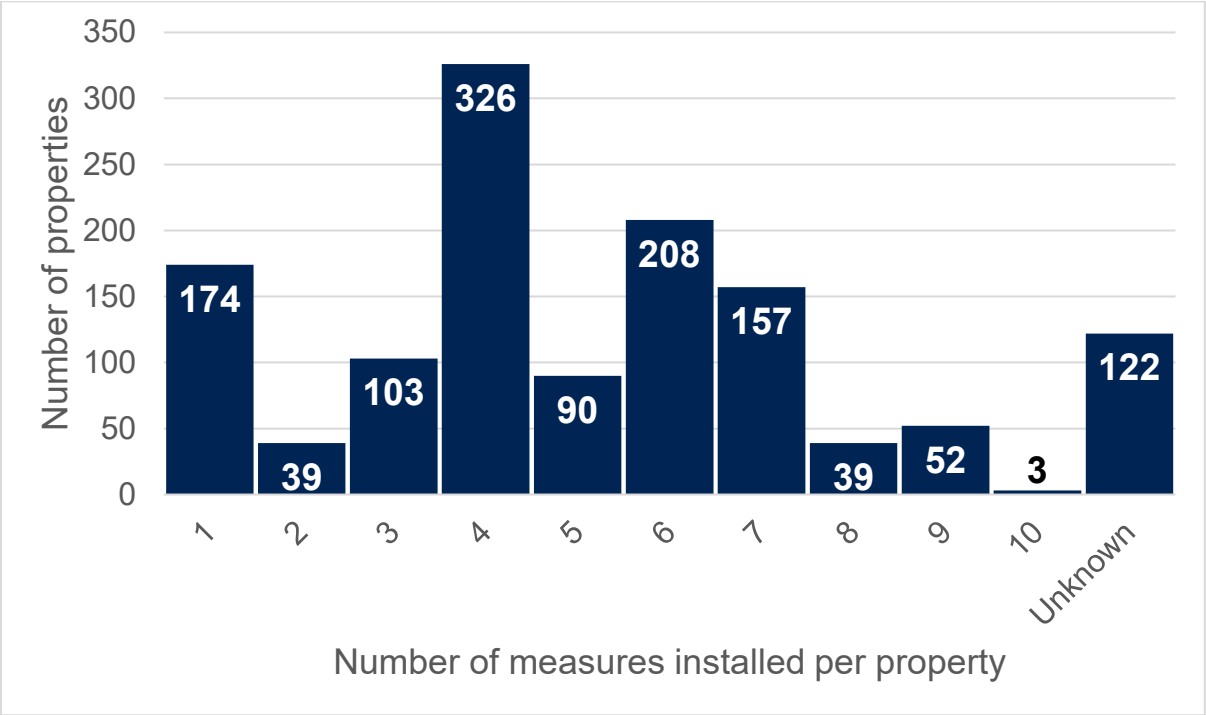
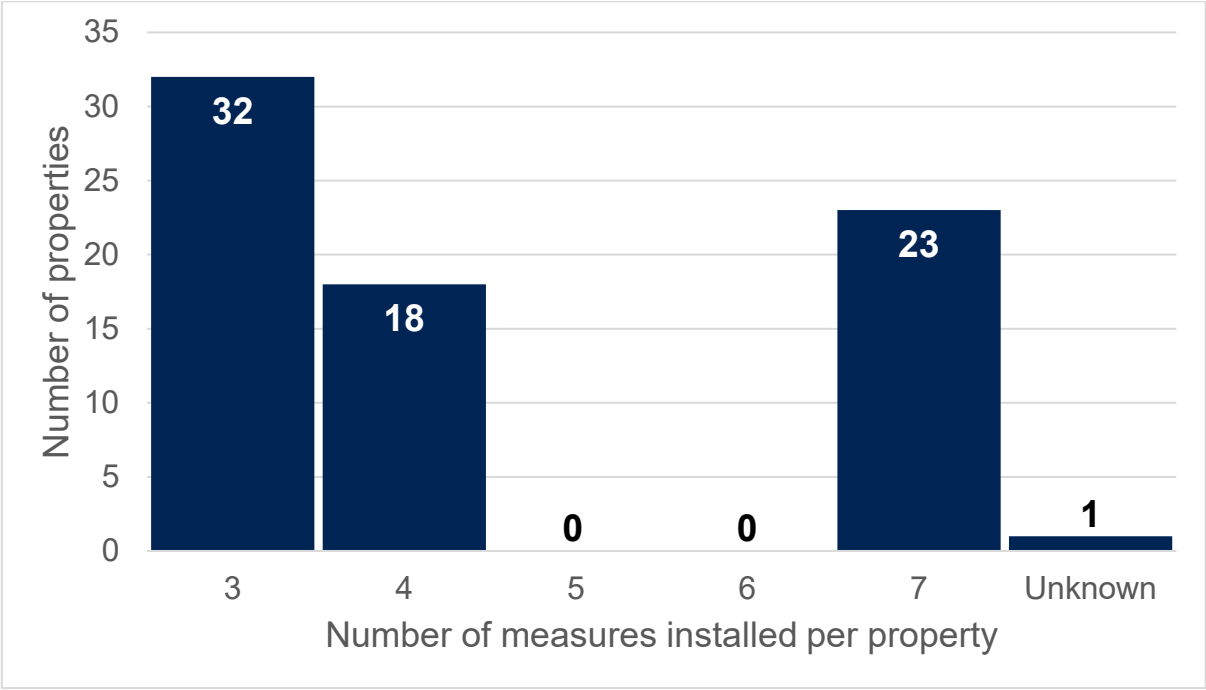


Figure 8: Numbers of measures installed in WHR properties, as of April 2023[39]



[38] The 122 unknown properties in SHDF(D) are in the projects Warmer Homes Argyll & Bute, Clarion Housing Group advanced retrofit project, National Net Zero Retrofit Accelerator, Leeds Whole House Retrofit, and Wychavon Retrofit of Electrically Heated Homes.
[39] The unknown property is part of the project Destination Zero I.

Table 3 below provides a comprehensive breakdown of the measures that have been implemented so far or are expected to be implemented by the end of the programmes, based on final project reporting, as of April 2023. The data demonstrates distinct differences in the distribution and focus of measures implemented between the two programmes, as described below in Table 2.

Table 3: Measures installed or expected to be installed under WHR and SHDF(D) as of April 2023

Measure	WHR #	WHR %	SHDF(D) #	SHDF(D) %
All insulation measures	**164**	**99%**	**2406**	**73%**
External wall insulation (EWI)	67	91%	949	73%
Loft insulation	73	99%	797	62%
Cavity wall insulation (CWI)	6	8%	261	20%
Roof insulation	0	0%	250	19%
Party wall insulation	0	0%	103	8%
Internal wall insulation (IWI)	0	0%	31	2%
Floor insulation	18	24%	15	1%
All Window and Door measures	**46**	**31%**	**1197**	**59%**
Doors	23	31%	428	33%
Windows	23	31%	769	59%
All Low Carbon Heat Measures	**46**	**31%**	**992**	**38%**
Heat Pump (all types)	23	31%	489	38%
Solar Photovoltaic (PV)	23	31%	346	27%
Hot water	0	0%	108	8%
Infrared	0	0%	47	4%
Storage heaters	0	0%	2	0%
Boiler upgrade	**0**	**0%**	**14**	**1%**

Measure	WHR #	WHR %	SHDF(D) #	SHDF(D) %
All ventilation	**0**	**0%**	**573**	**23%**
Mechanical extract ventilation (MEV)	0	0%	293	23%
Ventilation passive	0	0%	217	17%
Mechanical Ventilation with Heat Recovery (MVHR)	0	0%	63	5%
Number of properties (ongoing or completed) without data	**1**	**1%**	**102**	**8%**
Total number of properties	**74**	**100%**	**1293**	**100%**
Total number of measures	**256**		**5182**	

Source: Measures, as reported in project reporting. The table does not include information from one WHR property (from the project Destination Zero I) and 102 SHDF(D) properties (for the projects Warmer Homes Argyll & Bute, Clarion Housing Group advanced retrofit project, National Net Zero Retrofit Accelerator, and Leeds Whole House Retrofit).

Projects funded under WHR installed loft insulation at all properties, and EWI at the majority of properties. The most common combination of measures was EWI and loft insulation, which took place in 66 out of 74 properties.

Amongst SHDF(D) projects, the three most commonly installed measures were EWI (73% of properties), loft insulation (62%), and new windows (59%). Many properties also had heat pumps installed (38%), doors (33%), and solar PV (27%). A considerable number of properties also saw cavity wall insulation, roof insulation, and mechanical extract ventilation installed, demonstrating a broader range of energy efficiency interventions compared to WHR. Amongst SHDF(D) projects the most frequent combination of measures was EWI, loft insulation, and new windows, which was installed within 49% of the properties.

4.4 Resident profiles

Table 4 presents some indicative characteristics of the residents whose properties were retrofitted through the projects and who were included in the resident survey. The resident survey data is unweighted and therefore non-representative of the social housing population in the UK,[40] or the projects taking part in SHDF(D) and WHR. Nonetheless, it provides indicative

[40] More discussion of the limitations of the sample available for invitation and achieved in the online survey is provided in the Technical Annex

data on the profile of the residents benefitting from the two programmes as broadly comparable to the English and Scottish social housing population.

Table 4: Resident demographics from resident survey

Demographics	**Resident survey**	**English Housing Survey 2021-2022** (for those living in social housing only)	**Scottish Household Survey 2019** (social housing only – local authority and housing association)
18-64	68%	69%	77%
65+	31%	28%	20%
Lone occupiers	38%	43%	47%[41]
Full-time employment	33%	29%	26%
Part-time employment	16%	15%	11%
Unemployed and seeking work	17%	8%	8%
Retired / other	30%	49%	55%[42]
One or more of household with long-term illness or disability	53%	54%	59%[43]

Source: Resident Survey. Base: All respondents answering (253). Three out of the 14 SHDF(D) projects which reached the retrofit stage were Scottish projects (Warmer Homes Argyll and Bute, DORIC, Alva Community Regeneration through Decarbonisation). A total of 39 out of the 256 survey participants had participated in these projects (30 in the Warmer Homes Argyll and Bute project, eight in DORIC, and one in Alva Community Regeneration through Decarbonisation).

The survey found that 47% (n=119) of respondents took part in the projects because they wanted ‘to make their home warmer or more comfortable’, and a similar proportion (46%)

[41] Comprises single adults, single pensioners, and excludes single parents.
[42] Includes self-employed, training scheme.
[43] Whether any of the people in the household has any physical or mental health condition or illness lasting or expected to last 12 months or more.

wanted ‘to save money on energy bills’. The most widely selected reason was that ‘I had no choice landlord/building owner said that the work had to be done’ (50%, n=127).[44,45]

> *“Well, we thought... we didn’t have a choice really, but have since then we’ve realised some people have decided not to. But we thought it’s got to be better...we want to get away from using coal.” – Resident (Interview)*

Site visits carried out between May and July 2022 also found that residents were motivated to take part in the project due to growing concern regarding energy price increases and affordability. During another site visit carried out in May 2023, residents noted the importance of trust in the council, and that this had been a key factor in their decision to take part in the project.

[44] Q16. What were your reasons for having the energy-efficiency work? Please select all that apply (n=253, all respondents answering)

[45] Tenant engagement was reviewed and evaluated in the Whole House Retrofit and Social Housing Decarbonisation Fund Demonstrator: joint process evaluation published in June 2023 and available here https://www.gov.uk/government/publications/whole-house-retrofit-and-social-housing-decarbonisation-fund-demonstrator-joint-process-evaluation

5. Building performance outcomes

This chapter assesses the extent to which WHR and SHDF(D)-funded projects improved the performance of the properties retrofitted to the levels intended.

Chapter 5 at a glance

Several projects (those implemented in the localities of Clackmannanshire, Fenland, London (for WHR and SHDF(D)), Leeds and Wychavon) were successful at raising all or most properties retrofitted to EPC band A or B. In total 42% of properties within SHDF(D) and WHR achieved this, while 53% of the properties upgraded to EPC band C (95% achieved band C or higher). The remaining 5% of properties either upgraded to EPC band D only or did not experience an improvement in EPC rating.

Most properties retrofitted across both programmes were not projected to reach the ambitious space heating target of 50 kWh/m2 or below. In only four out of the 15 projects for which data were available, was the space heating target reached in more than 50% of properties treated.

Energy modelling conducted for this evaluation indicates that all retrofitted properties across both programmes achieved energy savings and associated carbon emissions reductions. On average, properties which had their heating systems upgraded to a heat pump from gas heating achieved higher energy and carbon savings, though lower energy bill savings than those that did not upgrade their heating system at all (electric or gas).

Almost all properties were modelled as likely to achieve savings on their bills.[46] Bill savings were calculated using 2023 energy prices; when using prices from 2021, prior to the sharp increase in energy prices in the winter of 2021-2022, modelled savings are 55-85% lower than when using 2023 values.

Most residents reported mould and heating issues with their homes were resolved following retrofit. However, insufficient time following installation has passed to confidently assess the effects of the retrofits on pre-existing issues in the home.

Although the resident survey found two in three residents felt confident using the new measures, findings from the qualitative research with residents indicated that the provision of information to support energy efficient behaviour and optimal use of the measures was lacking in many cases.

[46] The energy bills modelling used cost conversion data for the 2023 publication of the Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal data tables: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal. The analysis does not systematically take into account the effects of the sharp increase in energy prices in the winter of 2021-2022 on energy bills and this limits the accuracy of the analysis.

This chapter draws on project documentation up to April 2023[47] to model estimated energy, carbon and bill savings through delivered retrofits, and triangulates this evidence with interviews with projects, and a survey of and qualitative data collection with residents.

The chapter answers the following evaluation question:

- How much have whole house retrofits improved energy performance and why?
- What level of PAS2035/2030-compliance and build quality was achieved and why?
- Are occupants satisfied with the retrofits?

For the quantitative analysis of EPCs and energy performance in this chapter, energy savings (and associated carbon and bill savings) are based on modelled estimates using scheme data, including pre- and post-installation EPC records where possible, and do not reflect actual consumption data. For nine projects, data were analysed before all properties' retrofits were completed. The analysis is therefore based on predicted performance and may vary if the measures planned are not installed. The analysis uses the Standard Assessment Procedure (SAP) methodology[48]; it is therefore behaviour agnostic, and the actual savings may also vary depending on use. The full methodology for the analysis, including limitations to the approach, is set out in the Technical Annex.

5.1 How the schemes intended to support building performance and quality

Both the WHR and SHDF(D) programmes tested the deployment of deep retrofit using a whole house retrofit: a holistic approach to retrofit that reduces the space heating demand through the implementation of multiple energy efficient measures and considerations of the whole house. This includes the implementation of fabric measures (such as insulation), heating system upgrades (such as heat pumps) and renewable energy generation (such as solar photovoltaics (PV)). The whole house deep retrofit approach was anticipated to maximise the improvement in the property's energy efficiency, leading to a large-scale improvement in the EPC rating of the property compared to the installation of individual measures. In addition, the approach was seen to also maximise resident comfort by eliminating issues such as damp and mould, and limit disruption through coordinating the installation.

At a household level, WHR intended to contribute to an improvement in dwellings' energy performance and had a specific target of reducing space heat demand to 30kWh/m2/yr or

[47] Analysis for this chapter excludes the 20 communal spaces, as building performance estimates are based on assumptions that apply to domestic properties only. The total number of properties referred to in this chapter is therefore 1,293 (SHDF(D)) and 74 (WHR) properties (1,367 properties overall), which was correct at the time of analysis (April 2023).

[48] The Standard Assessment Procedure (SAP) is the methodology used by the government to assess and compare the energy and environmental performance of dwellings. Its purpose is to provide accurate and reliable assessments of dwellings that are needed to underpin energy and environmental policy initiatives. https://www.gov.uk/guidance/standard-assessment-procedure

50kWh/m2/yr where 30kWh/m2/yr is not viable. No EPC target was set, but projects with a starting EPC of A-C were considered in the business case as being ineligible for funding.

As with WHR, SHDF(D) was designed to improve the energy performance, safety, and comfort of retrofitted homes by funding high quality retrofits. SHDF(D) had a target of reducing space heat demand to 50kWh/m2/yr. With a focus on the whole house approach, SHDF(D) also specifically aimed to reduce negative outcomes associated with poor ventilation (mould, condensation, draughts) and cold spots (thermal bridges).

Within the context of analysis on energy performance, there are two key measure categories: fabric measures and heating measures. Fabric improvements refer to retrofit activity that treats the walls, roofs, internal surfaces, floors, stairs, landings, doors and windows. It excludes changes to energy generation and heating. The fabric of a building affects the amount of energy that is needed to heat the space in kWh/m2 in the property, discounting energy required for hot water and cooking. Heating measures include any changes to the heating system itself, such as a new heating system (where gas heating is replaced with direct electric heating, or with a heat pump), heating controls, or hot water systems.

Household energy use behaviour also affects the energy performance (overall) of a building, and it was assumed that WHR and SHDF(D) projects would support more efficient use of energy in the home post-retrofit through effective information sharing and guidance on how to use newly installed technologies and ventilation. This would help to ensure that energy, carbon and bill savings are maximised to their potential. For both programmes, it was expected that, through a programme of resident engagement, combined with the improvements in retrofitted homes, residents would be better able to use energy more efficiently in their home, thus leading to reductions in energy consumption and carbon emissions. By increasing the air quality and comfort of homes through a reduction in instances of damp, drafts and mould, homes would be made healthier, contributing to resident well-being and a better-quality housing stock.

5.2 Evidence of improvement in the energy performance of retrofitted properties

As part of the energy and thermal outcomes analysis, changes in EPC ratings were also modelled at a property level for each project. As set out in the Technical Annex, EPC ratings pre- and post-installation were either reported by project teams to DESNZ, or where there were data gaps, modelled by the evaluation team using a methodology similar to that used to create EPC ratings (the Dynamic Engine tool)[49]. Following this process, it was possible to estimate

[49] Dynamic Engine is a SAP based modelling tool which enables assessment of a property's energy use. https://www.solsticeassociates.com/#/Dyanmic-Engine This tool can replicate the calculations done on a typical EPC assessment. For more information, see the Technical Annex.

the change in EPC for 1,132 properties (83% of total properties treated across both programmes, as of April 2023); 235 properties were excluded (17%).

Tables 4 and 5 show the modelled EPC changes for WHR and SHDF(D) respectively, following retrofits. All 74 properties in WHR achieved an EPC rating of C or higher. For the 1,293 properties in SHDF(D) as of April 2023, 79% (n=1,019) achieved EPC band C or higher. Of the remaining 21%, 40 only achieved EPC band D (3%) and there was insufficient data to model estimated EPC changes for 234 (20%) of them.

Both the standard EPC approach and the evaluation team's method typically found that homes with energy efficient heating upgrades (especially where these are to low carbon heating) *and* solar PV (which offsets energy consumption) achieved higher EPC ratings. Subsequently 81% of properties retrofitted to EPC A under the programmes, for which EPC and measures data was available, had solar PV fitted.

Most properties without a heating system upgrade achieved a maximum EPC rating of C only. Of properties for which measure data were available, and which did not receive a heating system upgrade (n=208); only 8% (n=17) achieved EPC B. These properties had all received an extensive fabric package (EWI, new windows, doors, mechanical extract ventilation, loft insulation, party wall insulation, and lighting), indicating that fabric-only retrofit must be comprehensive to achieve higher than EPC C.

A total of 14 properties retrofitted through WHR (all part of the Energiesprong Sutton project) and 62 retrofitted through SHDF(D) had existing EPC ratings of band C and above. This was in instances where a project found that it was not practical to exclude these properties due to their location and proximity to other properties being retrofitted.

Table 5: Modelled changes to EPCs in properties retrofitted through WHR

	To EPC…			
From EPC…	**A**	**B**	**C**	**?**
C	2	12	0	0
D	7	2	11	0
E	0	0	37	0
F	0	0	2	0
?	0	0	0	1
Total	9 (12%)	14 (19%)	50 (68%)	1(1%)

Source: EPC ratings as reported in Final Reports, identified by the evaluation team using postcode data from final reports, or (for endline data) modelled using Energy Saving Trust's proprietary 'Standard Assessment Procedure' (SAP)-modelling method as described in the Technical Annex.

Table 6: Modelled changes to EPCs in properties retrofitted through SHDF(D)

	To EPC…				
From EPC…	**A**	**B**	**C/C+**	**D**	**?**
B	0	1	1	0	0
C	5	31	12	0	12
D	104	270	305	3	80
E	27	13	153	28	96
F	1	2	82	9	34
G	0	0	9	0	2
?	0	3	0	0	10
Total	**137 (11%)**	**320 (25%)**	**562 (43%)**	**40 (3%)**	**234 (18%)**

Source: EPC ratings as reported in Final Reports, identified by the evaluation team using postcode data from final reports, or (for endline data) modelled using Energy Saving Trust's proprietary SAP-modelling method as described in the Technical Annex.

5.3 Fabric improvements in retrofitted properties

5.3.1 The extent to which projects met the programmes' space-heating requirements

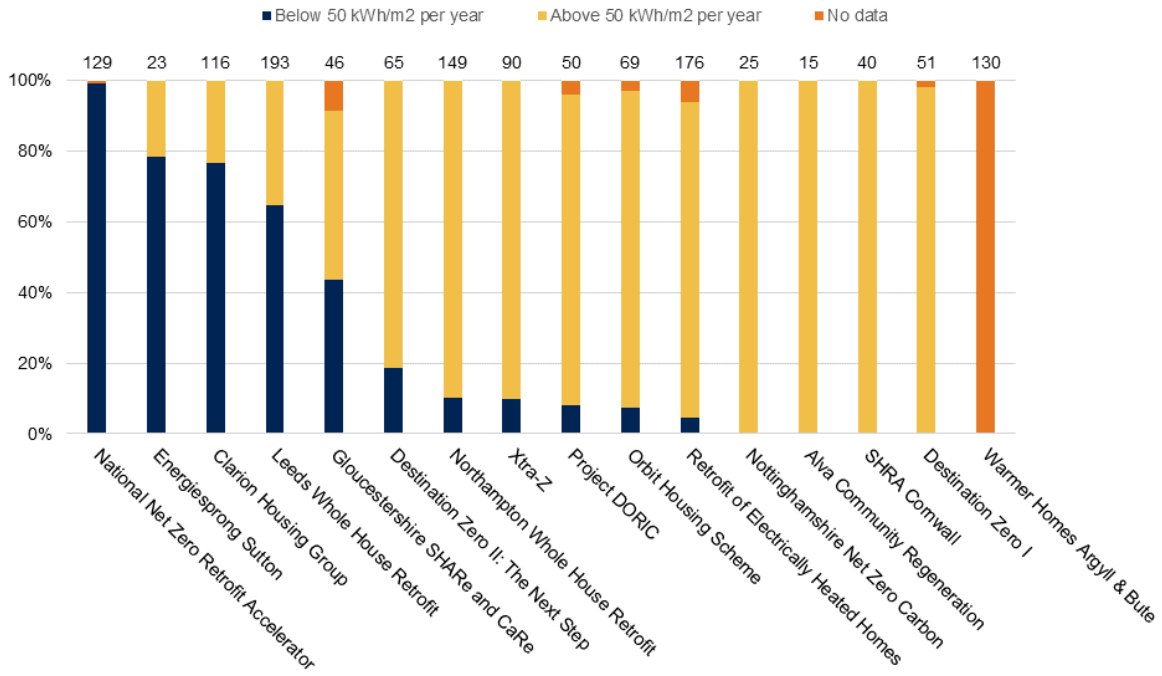
By improving the energy efficiency of the fabric, retrofits were expected to reduce the overall space heating energy demand. The evaluation team modelled the space heating demand pre- and post-installation for retrofitted properties, using data from projects alongside assumptions to calculate the property floor area and heating system efficiencies where there were data gaps, as detailed in the Technical Annex. The model was able to estimate the total fabric improvements for 1,231 properties (90% of properties treated across both programmes, as of April 2023).

Figure 9 shows that most properties retrofitted were not projected to reach the space heating target of 50 kWh/m2 or below. In only four out of the 15 projects for which data were available, was the space heating target reached in more than 50% of properties treated. At a programme level:

- One in three properties retrofitted under SHDF(D) (415 out of 1,157 properties (36%) for which space-heating-requirement data was available) were modelled to achieve 50 kWh/m2 or below.

One in four properties retrofitted under WHR (18 out of 74 (24%) of properties being retrofitted under WHR for which space heating requirement data was available) were modelled to achieve 50 kWh/m2 or below.

Figure 9: The number of properties in each project which were modelled to have achieved the space heating requirement target of 50 kWh/m2 per year



Source: Project reporting and SAP-modelled estimates. The number at the top indicates the number of properties retrofitted. Data was not available for Warmer Homes Argyll and Bute.

5.3.2 Fabric improvements by measure package

Properties had different combinations of retrofit measures installed. These combinations resulted in different levels of improvement in space heating requirement.[50]

- The properties with the greatest number of reported measures installed saw the greatest reductions in space heating requirement.
- Most retrofits that included heat pump installations resulted in space-heating-requirement decreases of over 100 kWh/m2/year.

[50] The full results of this change-by-measure-package analysis is presented in Annex 2 of the Technical Annex. However, there is inconsistent reporting quality across projects, so the findings are non-conclusive. For example, several properties were reported to have had only heat pumps installed, even though under the conditions of WHR and SHDF(D) this would have not been possible. The full presentation of results in the Technical Annex also sets out confidence intervals.

- The properties which saw the greatest decreases to their space heating requirements were those with very high (>200 kWh/m2/year) space heating requirement to begin with. Properties with a higher baseline space heating requirement were also typically the properties with the highest number of different measures installed.

5.4 Energy, bill and carbon savings

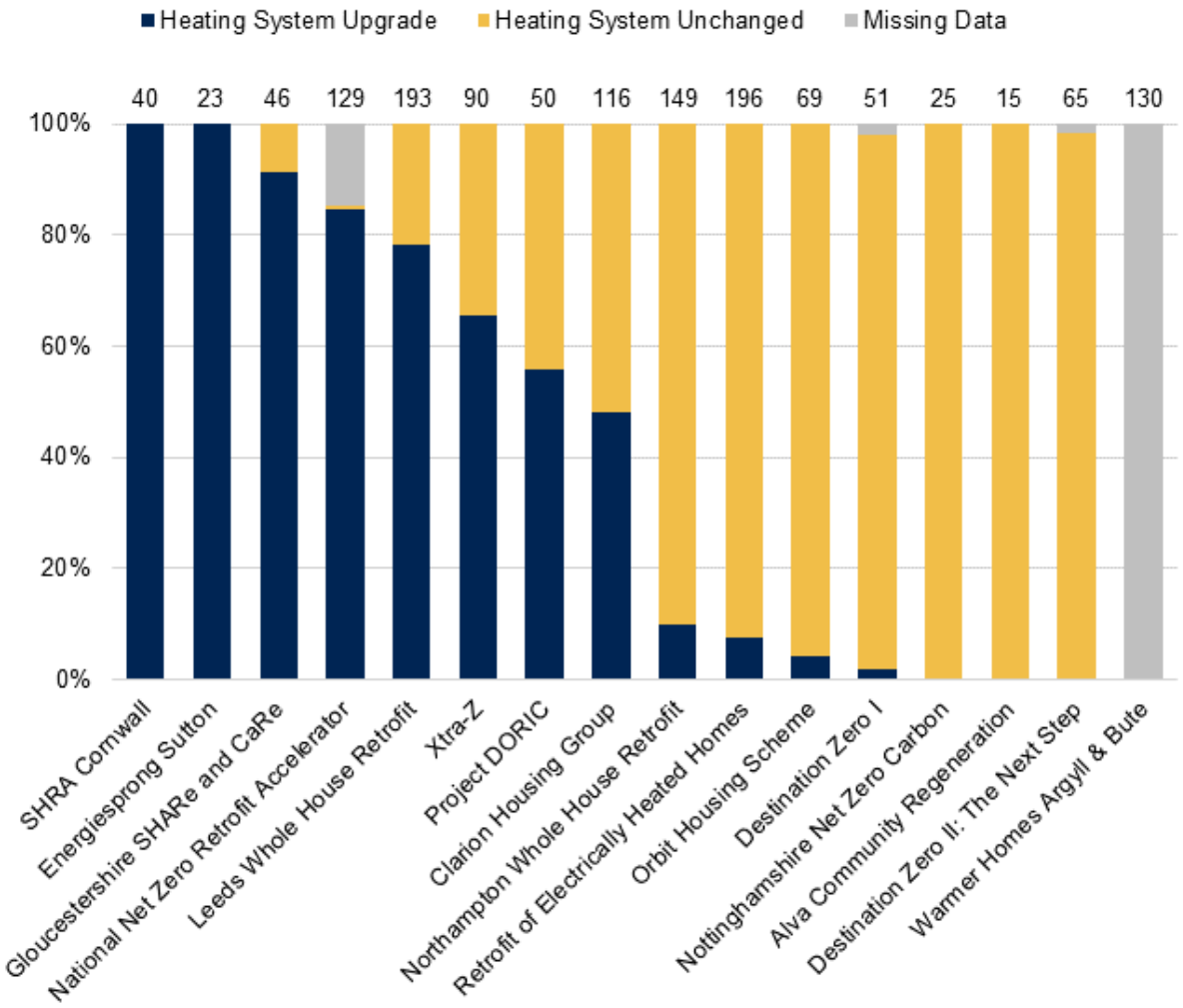
5.4.1 Energy savings

Based on the fabric improvement findings described in the previous section, and information on low-carbon measures installed, alongside assumptions about how such installations affect energy use in different types of properties, the evaluation team modelled the likely annual energy savings that would be saved per property post-retrofit.[51, 52]These outcomes are based on modelled data, rather than in-use measurements of real energy bills and should thus be treated with caution.

Due to incomplete scheme data and the atypical nature of the properties involved in the retrofit, with most of the housing in remote island communities, it was not possible to 'fill' data gaps with estimates based on standardised housing archetype data for the Warmer Homes Argyll and Bute SHDF(D) project. The project has therefore been excluded from this analysis. The model was able to estimate the energy, carbon and energy bill savings for 1210 properties (89% of total properties treated across both programmes, as of April 2023). Figure 10 provides an overview of the proportion of properties per project which underwent heating upgrades as opposed to fabric-only retrofitting.

[51] See Annex 2 in the Technical Annex for information on the assumptions underpinning the model.
[52] A modelled approach was taken as it was not possible to collect in-use data for a sufficient time period pre- and post-install over a winter period. Limitations of the approach are discussed at the start of this chapter and in the Technical Annex.

Figure 10: Percentage of properties by type of retrofit per project



Source: Project reporting, proxy data from EPC certificates, and modelled estimates. Heating system data was available or modelled for 1216 of 1367 properties across both programmes (89%). See the Technical Annex for more detail on the method.

Figure 11 shows the average modelled energy savings per property by heating system change. Overall, the model found that properties that received an upgrade to their heating system achieved significantly higher energy savings than those properties that did not. On average, per property, modelled energy savings (to a 95% confidence interval, meaning that there is a 95% likelihood that the effect can be attributed to the installation of a measure) were:

- 14,501 (± 534) kWh per year in properties upgrading a gas system to a heat pump.
- 8,516 (± 542) kWh per year in properties upgrading an electric system to a heat pump.
- 7,402 (± 317) kWh per year for properties which did not receive a heating system upgrade.

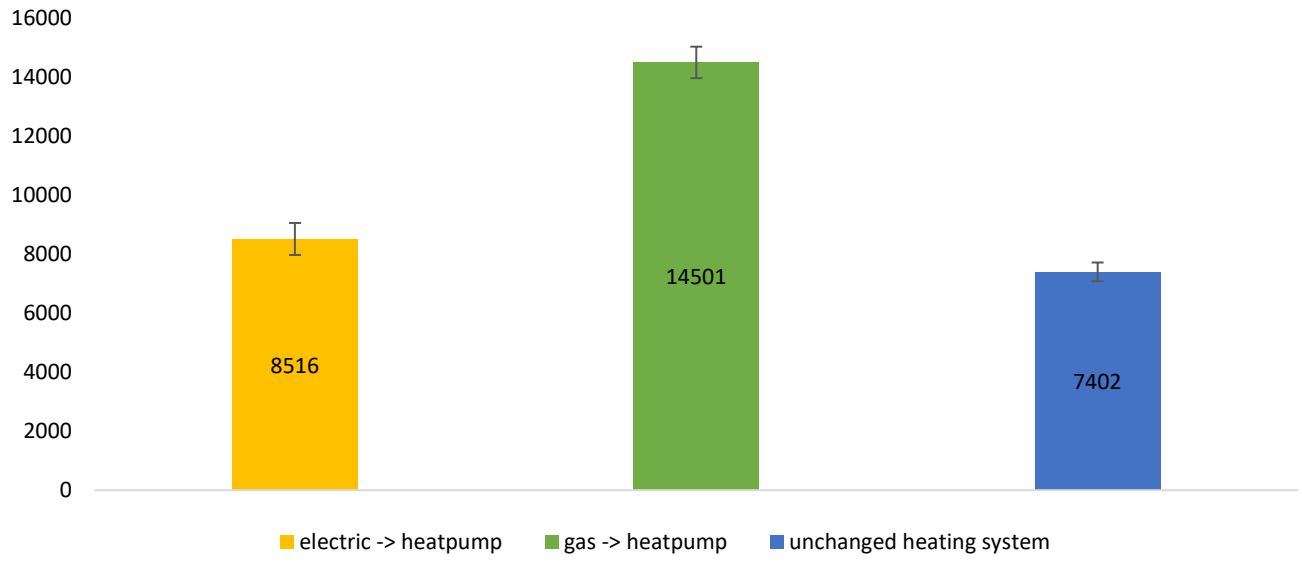
The larger increase in energy savings shown for properties upgrading from gas systems to a heat pump is due to less energy being imported (either gas or electricity) because of the very high efficiency of the heat pump (280% for both space and water heating based on data from

the Electrification of Heat trial[53]) compared to gas (86% and 73% for space and water heating, respectively).

One would expect savings from upgrading from an electric heating system to a heat pump to be on a similar level to upgrading from a gas system, with a possible difference in energy savings of around 20%, accounting for the difference in efficiency between gas and direct electric systems. Higher differences can only be explained by significantly different fabric improvements between gas and electrically heated homes pre-retrofit, or poor data quality.

The electric to heat pump savings, however, were modelled to be significantly lower - comparable to not changing the heating system at all. This may be due to the building differences in properties with electric heating and gas heating. For example, there may be more insulation already present in electrically heated homes, or fabric measures installed may not produce as high a savings as in gas heated properties. It is also important to note that the sample sizes for the model are also different, as only 112 properties had electric systems upgraded to a heat pump, compared to 427 properties which upgraded from gas systems. The mean energy saving in electrically heated properties may thus be underestimated due to the reduced sample size in the case of this evaluation.

Figure 11. Modelled average yearly energy savings per property in kWh



Source: Project reporting, proxy data, and modelled estimates. Base: electric to heat pump (112), gas to heat pump (427) and unchanged heating system (693). Gas to electric figures have been excluded since there were only two properties in this category. See the Technical Annex for more detail on the method.

[53] https://es.catapult.org.uk/news/heat-pumps-shown-to-be-three-times-more-efficient-than-gas-boilers/
For more information see table A16 of the technical annex

5.4.2 Energy bill savings and effects on carbon emissions

Using the energy savings modelled, the evaluation team applied standard conversion factors[54] to estimate the annual carbon emissions reductions and energy bill savings based on 2023 prices. Table 7 gives a summary of the estimated annual energy, carbon and bill savings for properties retrofitted under the two programmes. It shows that, on average, properties in both programmes are estimated to achieve annual energy, carbon and bill savings. Properties retrofitted through the SHDF(D) appear to have achieved slightly larger savings on a per property level than WHR.

Table 7: Summary of modelled annual energy, bill and carbon savings for the two programmes.

Programme	Combined	SHDF(D)	WHR
Number of properties analysed (% of total properties treated)	1,210 (89%)	1,137 (88%)	73 (99%)
Total Bill Savings (£000's)	1,538	1,492	47
Total Energy Savings (MWh)	12,045	11,493	552
Total Carbon Savings (tonnes CO2e)	2,109	2,011	98
Mean bill savings per property (£)	1,271± 56	1,312± 337	639± 73
Mean energy savings per property (kWh)	9,954 ± 325	10,108± 337	7,562± 337

[54] HMT (2022) Green Book Guidance on Appraisal and Evaluation in Central Government. Retrieved from: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent/the-green-book-2020 - supplementary guidance https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1150890/data-tables-1-19.xlsx For more information, please see the Technical Annex.

Programme	Combined	SHDF(D)	WHR
Mean carbon savings per property (kgCO2e)	1,743± 60	1,768± 63	1,346± 188

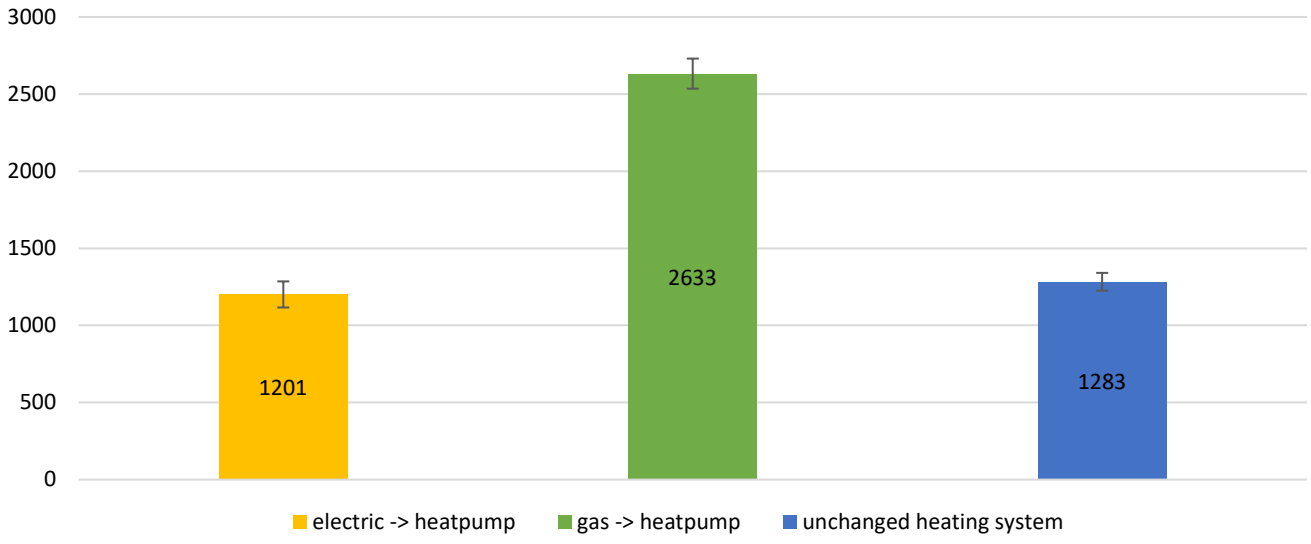
Source: Project reporting, proxy data, and modelled estimates. See the Technical Annex for more details. Per property savings have been calculated by dividing the total figures by the number of properties. Standard factors from the HMT Green Book (for 2023) were used to calculate energy bill and CO2e savings from a pre- and post-installation comparison of fuel types used for heating. The prices assumed were 41.70p/kWh for electricity, 11.30p/kWh for gas, 8.69p/kWh for LPG and 6.57p/kWh for heating oil. The associated carbon factors in kgCO2e/kWh were 0.146 for electricity, 0.183 for gas, 0.214 for LPG and 0.247 for heating oil. For detailed references, please the Technical Annex.

Figure 10 presents the estimated annual CO2e savings after the retrofit. Similar to energy savings, the largest CO2e saving occurred in properties where gas heating was replaced by a heat pump, with an average of 2633 (± 98) kg (95% confidence interval) of CO2e being saved each year in the 427 properties having this type of retrofit (95% confidence interval). As mentioned above, this resultant carbon saving is predominantly due to the high efficiency of heat pumps compared to gas.

The model found that in 693 properties where the heating system remained unchanged, an estimated average of 1,283 (± 58) kg of CO2e would be saved annually, due to the increased energy efficiency of the building through fabric improvements (95% confidence interval).

These results show that consistent carbon savings were estimated across both programmes, with properties which installed heat pumps reducing carbon emissions by the largest amount.

Figure 12: Modelled average CO2e savings per year in kgCO2e saved by retrofit

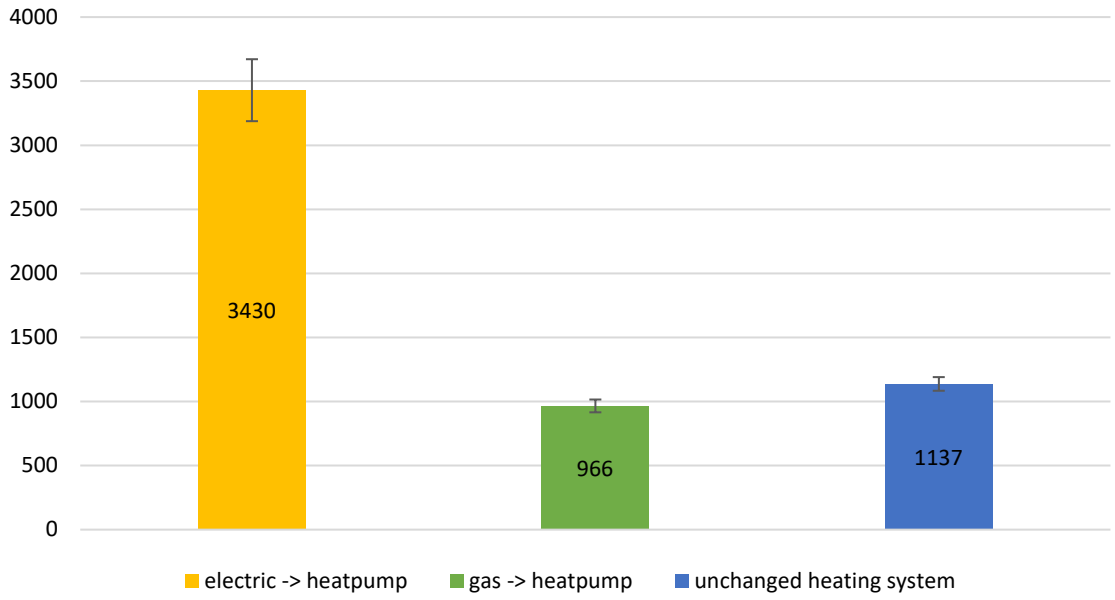


Source: Project reporting, proxy data, and modelled estimates. Base: electric to heat pump (112), gas to heat pump (427) and unchanged heating system (693) Gas to electric figures have been excluded since there were only two properties in this category. See the Technical Annex for more detail on the method.

Figure 11 shows the estimated average annual bill savings for properties retrofitted under both SHDF(D) and WHR, grouped by the heating system change.[55].

The largest average estimated bill savings were modelled as likely to occur in the 112 properties where an electric heating system was upgraded to a heat pump, with an average saving of £3,430 (± £242) (95% confidence interval). The model found that 427 properties where gas boilers were upgraded to heat pumps were likely to achieve significantly lower average savings of £966 (± £50) (95% confidence interval). This is comparable in magnitude to the retrofits without a heating system upgrade, which achieved savings of £1,137 (± £53) (95% confidence interval) and may be associated with the current high electricity prices reducing the overall financial savings.

Figure 13: Modelled average yearly energy bill savings per property in £.



Source: Project reporting, proxy data, and modelled estimates. Base: electric to heat pump (112), gas to heat pump (427) and unchanged heating system (693) Gas to electric figures have been excluded since there were only two properties in this category. See the Technical Annex for more detail on the method.

5.4.3 Influence of cost factors on bill savings

The above analysis made use of most recent HMT Green Book conversion factors available (2023). Fuel prices peaked in the year 2022/23 and have since stabilised; however, they remain significantly higher than 2021 levels. To establish what effect the change in prices may have on energy savings, the above analysis was re-run using the 2021 HMT Green Book

[55] 2023 UK Green Book and 2023 SAP (for LPG) factors were used to calculate energy bill savings from a pre- and post-installation comparison of fuel types used for heating. The prices assumed were 41.70p/kWh for electricity, 11.30p/kWh for gas, 8.69p/kWh for LPG and 6.57p/kWh for heating oil.

factors.[56] Overall, annual energy bill savings at 2021 prices were 71% lower than when modelled using 2023 prices, although this varies by type of retrofit as laid out in Table 6.

As discussed in section 5.4.2 above, this re-analysis also suggests that properties which switch from electric heating to a heat pump see the greatest projected energy bill savings.

Table 6: Comparison of modelled annual energy bill savings when using 2021 and 2023 energy prices.

Heating system	Annual bill savings – 2021 prices (£)	Annual bill savings – 2023 prices (£)	% change in bill savings from 2023 to 2021 prices
Electric to heat pump	1,540	3,430	55%
Gas to heat pump	170	966	82%
Unchanged heating system	408	1,137	64%
Total	424	1,271	71%

5.4.4 Energy performance improvement by measures installed

The analysis of estimated annual energy, carbon emissions and bill savings delivered through the SHDF(D) and WHR programmes, identified several trends by measure type. These are presented below.

- The greatest energy and carbon savings were achieved in properties which installed both a heat pump and solar panels. This comprised 245 properties, of which 240 had sufficiently good quality data to be included in the model. These modelled properties had an average annual CO2 saving of 2,378 (±134) kgCO2e and an average annual energy saving of 13,881 (±707) kWh. This highlights the energy and carbon savings benefits of low carbon heating coupled with solar PV electricity generation.
- The measure packages which generated space and water heating savings greater than 85% all included heat pumps. Only properties with both heat pumps and PV installations were able to reach savings greater than 90%. This percentage is in relation to energy

[56] Electricity cost: £0.1890/kWh (QEP 2.2.4 averaged over payment methods, UK average), Gas cost: £0.0342/kWh (QEP 2.2.4 averaged over payment methods, UK average), Heating oil: £0.0499/kWh (Unpublished prices provided by DESNZ, UK averages), Bulk LPG cost: £0.0676/kWh (Sutherland Tables for October 2021, using Quarterly Energy Prices 2020 Annual Domestic Bills Estimates Supplement for calorific value)

used for space and water heating, without considering lighting and appliances (which were assumed to be unchanged pre- and post-installation).

- EWI was universally applied across the projects and thus no pattern could be observed in studying how effective it is in combination with other measures.
- Mechanical ventilation with heat recovery (MVHR), installed in 30 properties alongside a heat pump and solar PV, resulted in estimated annual savings of 20,840 (±1,140) kWh, 3,665 (±205) kgCO2e and £1,575 (±102), suggesting this measure is a large contributor to energy savings.
- Properties which received a heating system upgrade were consistently modelled as achieving energy savings of 10 000 – 25 000 kWh, 1,500 – 5,000 kg CO2e and £1,000 - £3,500 in energy bill savings per year.
- Properties where the heating system remained unchanged (i.e. properties which only received insulation measures and/or solar panels) generally saw lower energy savings in the range of 2,000 – 15,000 kWh, 300 – 1,000 kg of CO2e and £300 - £1,500 off their annual energy bills. This suggests the adoption of low carbon heat measures are necessary to achieve the greatest energy savings.

5.5 Residents' perceptions of changes to their bills

Energy bill savings were also explored with participants of the resident survey and through qualitative research.[57]

When asked if they had seen any changes to their household energy bills since the installations were completed, 37% (n=56) of respondents to the resident survey felt their bills have become cheaper as a result of the work, 14% said they have seen no change, 28% weren't sure, and 20% said their bills were more expensive.[58] Of those who felt bills had increased, a follow up question was asked to understand whether they felt it was of a direct result of the work, or due to the increases in energy prices as a whole – 45% (n=13) stated they felt the bills were higher because of the work. [59] This conflicts with the results of the energy savings modelling reported above, which suggested that almost all properties reported energy savings.

However, the energy savings modelling did not control for the wider economic context – it assumed the same energy prices pre- and post-retrofit. The significant increase in energy

[57] The resident survey (January to April 2023) took place at the same time as the current period of atypically high energy bills. Therefore, residents' responses may have been affected by the significant energy price rises experienced since the spring of 2022 and publicised concerns around energy security.
[58] Q21. Have you seen any changes to your household energy bills since the work has been completed? (Base: All respondents (answering) whose work has been completed, 152)
[59] Q22. You mentioned that your bills are more expensive since the work has been completed. Given that the national cost of energy has risen sharply over the last few months, do you feel that the work has prevented your bills from rising even further, or not? (Base: All respondents (answering) who have seen energy bills rise since work has been completed, 29)

prices experienced since the spring of 2022, and widely documented concern for cost of living implications, may explain why one in five residents would perceive increased energy costs. It is also possible that perceptions of heat pumps and their associated running costs may have driven the participants' responses around higher energy bills, however due to small sample size, it is not possible to disaggregate the data further by measure type.

When asked about the impact of works on energy bills during the qualitative interviews, residents reflected that changes to energy prices made this difficult to determine. Energy prices significantly increased during the installation period, which meant that all bills had risen irrespective of the new measures. Despite 37% of survey participants reporting a decrease in bills, only a small number of interview participants noted this. In these instances, participants noted it was because they no longer had to pay a gas bill or, because their home was warmer, they were not using as much heating as they had previously.

> *"Where everybody's bill has doubled, ours has dropped a little bit…because the heating is so much cheaper to run…Solar panels made a big difference [and the] warmth stays in with insulation." – Resident (Interview)*

In some cases, participants assumed that the installation works had provided cost savings which were offsetting the increase in energy prices, and residents also frequently noted that they had reduced their energy usage due to cost of living concerns.

> *"[We're] paying about the same, when you factor in we used to buy coal as well...Not bad when you think everyone is paying a lot more...Some people are paying way more than they used to, [so it's] not bad in the crisis." – Resident (Interview)*

Importantly, residents were often unsure of how different measures were impacting bills. For example, they were unsure how much, if any, energy they were using was now generated from the solar panels or were unsure how new windows and doors would contribute to overall bill savings. Determining the impact of measures on bills was further difficult to ascertain for residents who had not yet received a bill or were on a fixed price tariff, as for many residents, works had only recently completed.

5.6 Quality of retrofit installations

The quality of a retrofit can have a significant effect on the overall energy performance of the property and the extent to which residents perceive it to be warm, comfortable, spacious and aesthetically pleasing. As part of the evaluation, through data collection with residents, project teams, and TrustMark, the quality of retrofits under both programmes was assessed in terms of resident satisfaction, compliance with PAS2035/2030 (SHDF(D) only) and stock assessment property condition ratings.

Across both WHR and SHDF(D), it was anticipated that resident engagement, resident satisfaction, and information provision to residents would play a key role for the projects in meeting their objectives and those of the programmes. Wider literature and evidence collected during the process evaluation supports this.

Following the Decent Homes Standard[60] introduced in 2000, the Government began to place greater importance on resident engagement during retrofits. A key lesson of the research was the need to engage residents to "increase their understanding and acceptance of the works" which can be a defining factor for success of retrofit programmes.[61] The process evaluation of the SHDF(D) and WHR programmes found that – at design stage, pre-retrofit stage and the initial stages of retrofit – projects were, on the whole, planning for and carrying out resident engagement to largely satisfactory levels, though these findings came mainly from the perspectives of project teams, as no systematic resident research was conducted for the process evaluation.

The PAS2035/2030 process also guided DESNZ's expectations about resident engagement and satisfaction (as well as quality) when designing and setting objectives for the programmes, although PAS2035/2030 was not mandated for WHR. The standard outlines detailed requirements for achieving anticipated minimum levels of quality and assurance, and it also sets out processes to be used to ensure the retrofit is fit for purpose, long lasting, and risks of unintended consequences minimised. PAS2035/2030 processes and how they were applied and experienced by project teams have been described in detail in the process evaluation.

5.6.2 Residents' satisfaction with installations

The resident survey and qualitative research asked residents about their satisfaction with the installations, finding that satisfaction was directly impacted by experience during the retrofit, particularly of the works taking place.

In discussing this experience, it is important to note that retrofits had not always been completed at the time the residents survey was carried out in January to April 2023. Amongst survey participants, retrofits were reported as complete for two-thirds of respondents (61%, n=154), and as incomplete for one-third (33%).[62] Resident interviews took place between November 2022 – March 2023 and covered 10 projects. In some cases, residents interviewed had had all works completed, excluding snagging, for a number of months, but in other cases, residents were still waiting for follow-up work, including final fixes, to be completed. In some cases, residents interviewed were part way through works, meaning that not all measures had been installed. This meant that interview feedback and resident satisfaction was often

60 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/7812/138355.pdf

61 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/669113/Retrofit_for_the_future_-_A_guide_to_making_retrofit_work_-_2014.pdf

62 Q14. Has the work on your property been completed? (Base : All respondents (answering), 252)

influenced by ongoing installation experiences, or with installation experiences fresh in their mind.

Overall, four key factors emerged in the research as influencing resident satisfaction during the works:

- Timeliness
- Resolution of issues
- Disruption
- Communications.

Timeliness: Residents were dissatisfied with the length of time the installations were taking. Of those with retrofits complete, over two-thirds (67%, n=103) said that the work took longer than they expected it to.[63] Generally, those who said that the work took longer to complete than expected were significantly more likely to be dissatisfied in relation to the installation. For example, 50% (n=52) of those who said that the work took longer to complete were dissatisfied with how long they had to wait for the installation to be scheduled versus 26% who were satisfied. [64] Qualitative research also found that delays increased disruption and created a sense of frustration.

Resolution of issues: A key driver of resident satisfaction was effective resolution of issues. In interviews, residents described positive experiences where installers and/or delivery teams had been easy to contact and were responsive. For example, where project teams arranged for speedy resolution of issues in the property.

> *"Only problem I had was that the system dropped out once, [but] someone from the installation company came and told us how to get pressure back up. The workers that did the insulation were superb, I can't fault them." – Resident (Interview)*

Where issues were not dealt with effectively or efficiently, residents were much less likely to be satisfied with the work and the retrofit overall. In some cases, residents interviewed were still waiting for issues to be fixed at the time of the interview and were unsure when / whether the resolution would happen.

Disruption: The role that disruption played in resident satisfaction varied. Views collected in the resident survey were polarised, with 40% (n=100) of survey respondents saying they were satisfied overall with the level of disruption, and 41% (n=102) saying they were dissatisfied. Across qualitative interviews, residents described difficulties with noise, mess inside the home and in the garden, having workers in the home, and scaffolding blocking out sunlight. Where

[63] Q18. Thinking about the time it took to complete the energy-efficiency work, how did this compare with your expectations? Base: all respondents answering who had work completed (n=153)
[64] Q17. Thinking about the installation process, to what extent were you satisfied or dissatisfied with the following? Base: all respondents answering (Communication from the local authority / your landlord n=249), (General disruption to you / your household n=249), (Communication from installers n= 248)

particularly dissatisfied with these experiences, this tended to have an over-arching impact on how residents viewed the retrofit overall. Even where measures were working as expected, the participant often focused on the disruption experienced. In these instances, the participant was unlikely to view the retrofit positively, and/or not want to take part in a similar scheme in the future. Where participants were satisfied, their overriding viewpoint was that the disruption was 'worth it' – this tended to be where disruption was kept to a minimum and the measures installed were working as expected.

Communication: Positive experiences of communications before and during works played a role in overall resident satisfaction. However, the survey found mixed experiences of communications amongst residents. Half of residents (50%, n=124) said they were satisfied with the 'communication from the local authority / landlord', and slightly less (48%, n=118) said they were satisfied with the 'communication from installers'. Survey respondents who were dissatisfied with the communication were significantly more likely to be dissatisfied at an overall level. For example, of those who said they were dissatisfied with the communication from the local authority / landlord, two thirds (60%, n=30) stated they were dissatisfied with the overall impact the work has on those living in the home.[65]

In interviews, residents noted that they appreciated upfront detail about the process; the opportunity to ask questions and having a named contact. By providing information prior to works taking place, project teams set expectations and increased the likelihood of a positive start to the process. Residents' reported frustration when they felt information provided was inaccurate or misleading. For example, the initial communication might have included detail about solar panels, which were then not offered as part of the retrofit.

> *"They told me they would install solar panels; this is the main reason I did it. Then they just didn't, and they never mentioned it again." – Resident (Interview)*

5.6.3 New issues as a result of poor-quality works

Whilst infrequently raised, there were mentions of new issues in the home which had been caused by the installation works and had not previously been a problem in the property. Residents reported that these issues were typically caused by poor quality of installation works. In one case, a participant noted that poor workmanship had created additional draughts in her home which were not present before.

> *"They were going to do the underfloor foam thing as the breeze comes up through the floorboards, it's freezing, and I thought how wonderful to be able to put my feet down on the floor but - oh no - if anything, it is worse." – Resident (Interview)*

Other issues reported including painting and decorating defects, fixing marks and holes made to walls, completing plastering around windows and carpet fixes or replacement where

[65] Q25. And, overall, how satisfied, or dissatisfied are you with the impact the energy-efficiency work has had on those living in the property? Base: all respondents answering (n=245)

previous measures had been removed (e.g. night storage heaters). There were also mentions of issues with snagging. Whilst some residents noted that snagging had been resolved, others were still waiting for these to be fixed.

> *"Quality of rendering was subpar and had to be redone. The subcontractors had to come again and again." – Resident (Interview)*

Residents also reported that some measures were not working as expected. For example, a few residents mentioned they were waiting for radiator parts or a replacement smart meter.

Where new issues had been created, it meant that residents were not receiving the benefits of the whole house approach, and the home was not as energy efficient as intended. These participants were less likely in interview to report a reduction in bills and in some cases said that these were higher. These participants also voiced frustration with lack of resolution of these issues at the time of interview and expressed dissatisfaction with the retrofit overall.

Mobile Diary Task (AppLife): New issues in the home

Across the mobile diary task participants were asked to explain how the measures were working in their homes – including whether they were satisfied with them and whether there were any outstanding issues.

One resident explained that a window newly fitted through the retrofit that was creating a draught. Despite raising the issue, it had not yet been resolved at the time of the interview.

"I would say the only issue that I've had with the work that has been done is my kitchen window. The window doesn't click, doesn't shut properly. And when it's really windy I get draughts through the kitchen because there's air getting in somewhere. They came round a couple of times to look at it. Once they changed the handle, [but that] didn't do anything. They were a bit puzzled about what was wrong with it, and since then nothing was done about it whatsoever." – Resident (AppLife mobile diary research)

5.6.4 Change to draughts, cold spots, mould, damp and condensation conditions

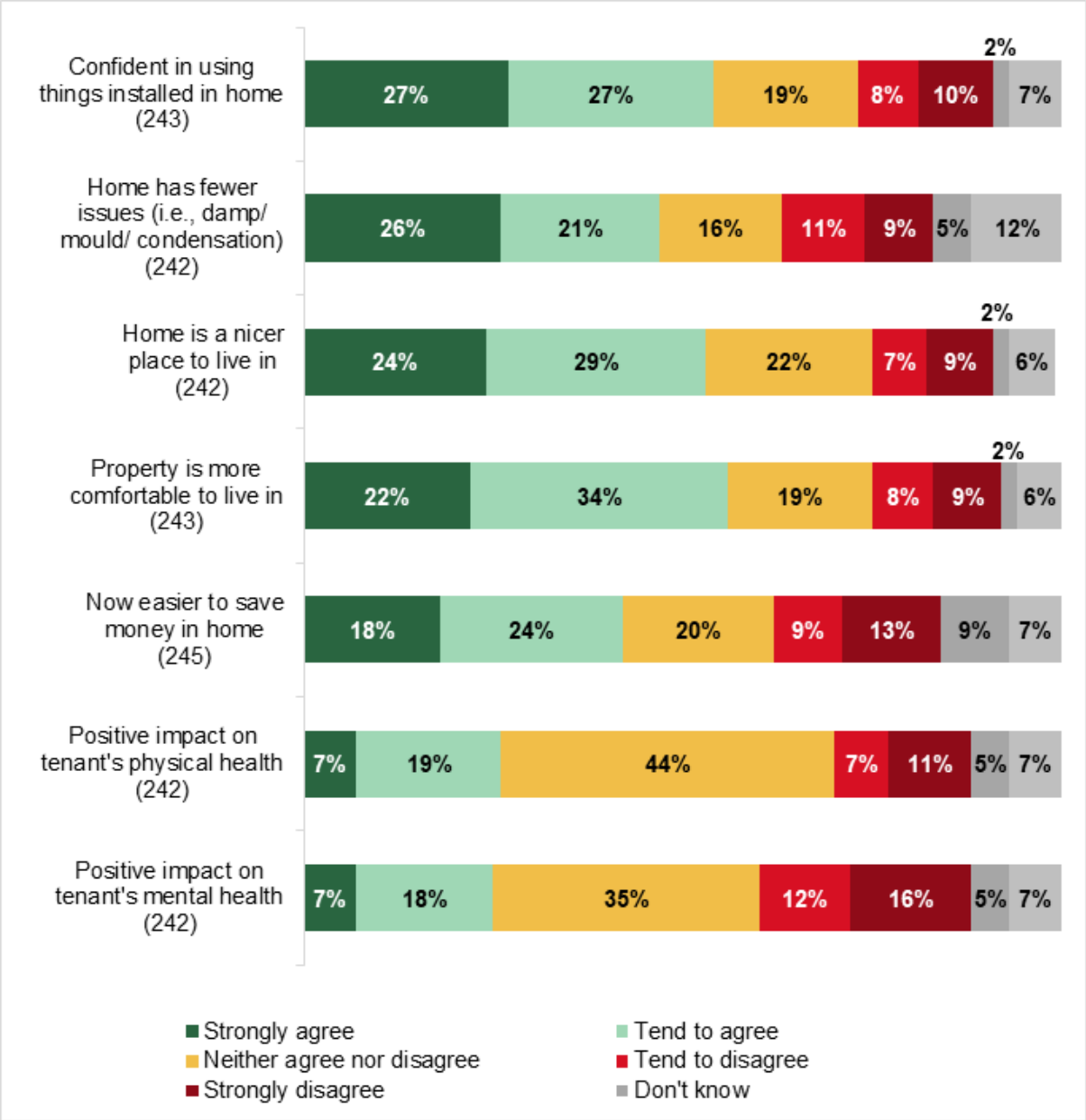
PAS2035/2030 is designed to ensure the risk of unintended consequences, including mould and damp, is minimised. This includes a whole dwelling assessment which will include an assessment of existing ventilation.[66] Most projects responded to this requirement by completing ventilation assessments pre-retrofit, and six months' live monitoring post-retrofit.

Most residents interviewed through the resident research reported that pre-existing issues (reported in chapter 4) had often been resolved. The survey asked residents to what extent

[66] The existing ventilation is deemed inadequate if there is evidence of mould and/or condensation, there is no ventilation system, or the ventilation system is incomplete or not working, and/or there is no provision for purge ventilation of each habitable room (e.g. by opening windows).

they agreed or disagreed that the energy-efficiency work had resulted in fewer issues in the home. Of those who have had the work completed, over half of residents (55%, n=83) agreed that 'my home has fewer issues like damp, mould and condensation'.[67]

Figure 14: Resident Survey, Q23 To what extent do you agree or disagree with the following statements in relation to the energy-efficiency work that has been installed in your property.



In the qualitative research, residents noted that new doors and windows tended to solve issues of condensation, rot in window frames, and draughts; insulation and new heating systems

[67] Q23. To what extent do you agree or disagree with the following statements in relation to the energy-efficiency work that has been installed in your property? My home has fewer issues like damp, mould and condensation, Base: all respondents answering with work completed (n=151)

made the home more efficient to heat and, in some cases, cheaper to heat; and mould and mildew had not returned.

> *"Since the double glazing, the condensation is gone." – Resident (Interview)*

> *"Guttering was replaced, and I guess it dried out after that, mould wiped off, gone and don't come back." – Resident (Interview)*

However, this was not the case for all residents. A quarter of the participants in the resident survey (24%, n=23) who reported a mould/mildew problem prior to the installation stated that they were dissatisfied with the impact the work has had on the property, significantly higher than the average (20%).

Although infrequent, in interviews residents noted that there were instances where previous issues had not been resolved. For example, one resident mentioned that their kitchen was very cold, and although work had been done to address this issue, including draught proofing and insulation, the kitchen is still cold. The resident said that they felt this was because of the extractor fans which had been installed as part of the retrofit.

> *"Cold spots are still there… [The workers] insulated the walls there and filled the gaps in the walls… [It's] a little bit warmer in the kitchen, but still freezing because of the extractor fans." – Resident (Interview)*

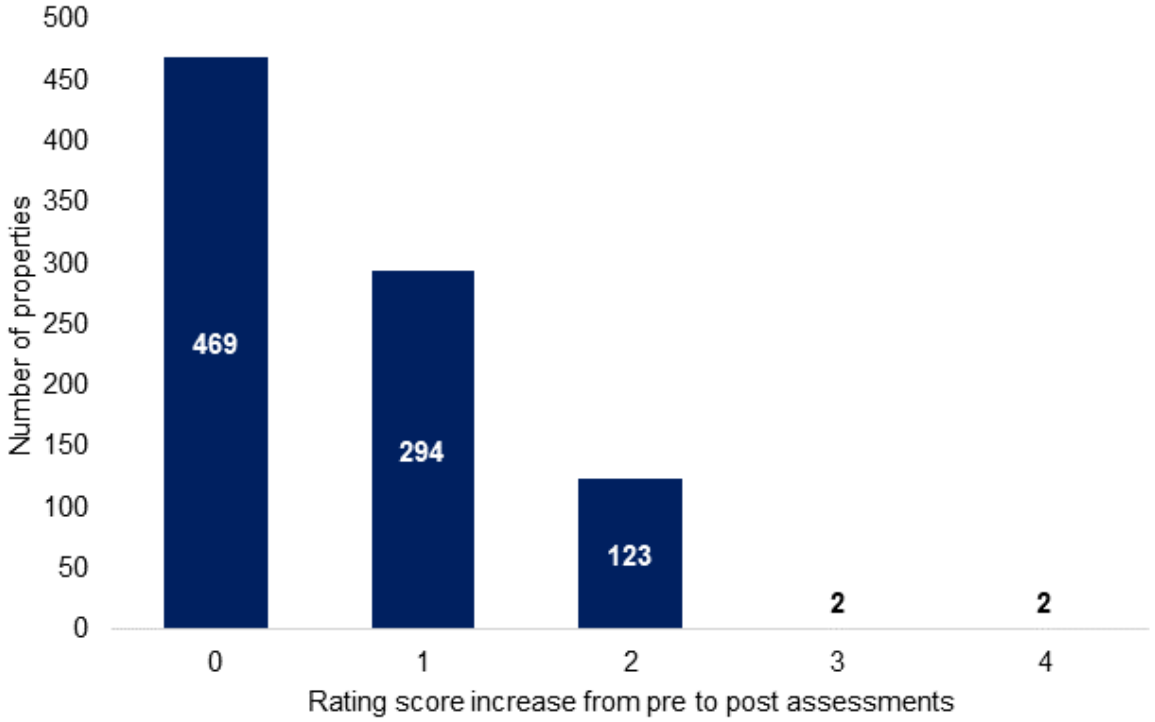
Analysis of secondary data was used to validate resident evidence on the condition of SHDF(D) and WHR treated properties pre-installation, and in some cases post-installation as well, to assess improvements in property conditions. Property condition in social housing is normally determined by an in-house or third party 'stock condition assessor' as part of a stock assessment survey, to comply with the Decent Homes Standard.[68] The details of what is included in an assessment will vary between landlords but will typically include the general condition of kitchens, bathrooms, fittings etc. and any building faults such as structural failure/damage and damp. Stock condition assessments do not normally include energy performance assessment. A score of 1 to 5 is provided with 1 being very poor: homes that are in disrepair or deterioration through neglect and/or structurally unsound requiring major repair and 5 very good: homes that are in good condition and exceed the minimum requirements, without any repairs or refinishing required. It should be noted that there is not a standardised approach to scoring property condition assessments and the degree to which the scoring is representative can be impacted by how recent the assessment was conducted.

[68] This assessment is separate to work under PAS2035/2030, the stock condition survey is undertaken to comply with the Decent Homes Standard to ensure properties are safe and maintained to a decent standard. There is some cross over with PAS2035/2030 as the stock condition survey will identify issues with mould and damp which can be addressed by retrofits covered by PAS2035.2030 but the assessment undertaken for the stock assessment will only cover part of what is covered by a PAS evaluator.

5.6.5 Findings from pre- and post-installation property condition assessments

All SHDF(D) and WHR projects had pre-retrofit property condition assessments available through project documentation,[69] and for 890 properties (74% of the 1,207 completed properties as of April 2023) post-retrofit assessments had been undertaken. To assess improvement in property condition, the assessment scores before and after the retrofit have been analysed. Figure 13 shows the number of properties that experienced an increase in the rating score given. It shows that almost half (47%) of 890 properties, where data is known both before and after retrofit, received an improved property rating following the installations. The average score pre retrofit was 3.1 and post retrofit was 3.7. For the reasons explained above, these results should be viewed with some caution.

Figure 15: Improvement in property condition rating



Source: Project reporting. Base: 890 properties where pre- and post-retrofit property condition assessment data was available, there are an additional 477 properties that did not have a post-retrofit assessment available and so these have not been included in the chart.

5.6.6 PAS2035/2030 compliance

PAS2035 was published in June 2019, the same time as WHR was launched and only 15 months prior to the launch of SHDF(D). This meant that many organisations had little or no experience of PAS2035/2030 prior to working on the programmes (PAS2035/2030 was not mandated for WHR). Interview data reveals different impacts of PAS2035/2030 on installer behaviour. Project team members and project leads interviewed for this evaluation explained

[69] Information is not available on when the pre-retrofit property condition assessments were completed, although they are usually completed every five years as a minimum.

that PAS2035/2030 presented challenges in terms of understanding and executing the required level of upgrade.

> *"Many of the contractors still don't get the concept and the level of upgrade. They want to do things as they have always done them." – Project lead (interview)*

However, others commented that the quality of the work improved as time went on as contractors got used to what they needed to do.

> *"[PAS2035 has meant that installers and contractors] think a lot more deeply about [the] job and whether they are satisfying the requirements." – Project lead (interview)*

> *"[PAS2035] has contributed to a departure away from 'cheapest rules'." – Project lead (interview)*

Project team members and project leads described how they undertook multiple inspections and repeat visits to rectify issues. Some were satisfied with the compliance and quality of the measures once issues had been rectified but others were not satisfied with the quality on completion of works.

> *"There were quite a few [installations] that weren't good enough and needed rectifying. But the final outcome has been good." – Project team member (interview)*

Some team members responsible for delivering projects considered that PAS2035/2030 had some negative effects on quality. A participating architect felt that budget constraints impacted the finished design in terms of the quality of the external appearance of the properties and neighbourhood aesthetics. PAS roles and responsibilities was a primary theme in research on PAS2035/2030 implementation conducted as part of this evaluation. Secondary themes included conflicts of interest in PAS roles and design challenges and touched on the implementation challenges faced by project team members responsible for different aspects of the PAS2035/2030 process (i.e. coordination, design etc.).

PAS2035 takes a holistic view of a building including tenant wellbeing, building fabric, building services (e.g. ventilation, heating and cooling, controls, water, lighting) and low or zero carbon technologies. There is mixed evidence of the success of this approach amongst SHDF(D) and WHR projects (see section 5.6.2 and 5.6.3 and the quotes below).

> *"The insulation in the loft and the ventilation all works quite well together." – Resident (interview)*

> *"All measures…came together to make our home feel warmer." – Resident (interview)*

PAS2035 also aims to support a more structured approach to retrofit project management. Some project teams commented that by following PAS2035 requirements, contractors adapted their approach continually in line with lessons learned and held fortnightly progress meetings to assess delivery issues and identify solutions.

A final issue raised linked to PAS2035 and quality was the role of innovation and that PAS2035 made this difficult.

> *"There was a challenging drive for off-site innovation, PAS2035 is not keeping up with the solutions required." – Project team member (interview)*

Whilst this was only mentioned by one project team interview, this is supported by other fieldwork evidence conducted for this evaluation and other secondary research that highlights the challenges of demonstrating how innovative measures will perform when used in combination with other measures.[70]

5.7 Evidence of changes in residents' use of energy in the home and other post-retrofit behaviours

Energy behaviours post-completion were typically driven by whether participants felt informed about their new measures including how to use them and how they contributed to levels of energy consumption, and to what extent the works changed existing energy use habits. Evidence from the survey and interviews found that residents had a mixed understanding of how to use the measures and therefore energy in the home. Resident behaviour is an important component for energy saving but is dependent on measures being used optimally.

The survey asked residents with completed works how confident they felt in using things installed in the home. Two-thirds of respondents (64%, n=96) agreed that they were confident in using the new measures.

Across the qualitative research, confidence in using new measures tended to be positively influenced by receiving clear information and a demonstration or explanation for how measures worked. Those who had received this type of demonstration noted that this had been 'ad hoc' and because they had been at home when someone who knew about the measure was on site. For example, during installation or when someone had visited to look at the installations.

Lack of confidence or certainty about using measures, or how measures worked was more likely to be raised in relation to complex measures or those with automatic settings such as heating systems. Participants were not always clear on how to change settings. For example, one participant described how they just turned their heating on and off as they were not sure

[70] Sustainable Energy Association (2022) 'Helpful Information and Tips for Manufacturers and Innovators on Gaining Access to Government Energy Efficiency Schemes'

about any other settings. This understanding was particularly limited for those who noted that they had not received guidance or found the information provided too complex.

> *"You need to be a rocket scientist to understand it [the instruction manual on how to use the heat pump]…it is unbelievably overwhelming." – Resident (Interview)*

With more complex measures such as those with automated systems such as solar panels and heat pumps, even if the resident felt confident in using them (because they were automatic), they were not always clear on how they would change any settings if needed, how these worked, or how they contributed to energy efficiency. Often, participants said these measures had been set up and they did not touch them, even to change the settings, because they did not know how to.

Mobile Diary Task (AppLife): Post-retrofit behaviours

Across the mobile diary task participants were asked to tell us about their home heating systems, how they used these and how confident they felt in using these.

Those expressing low levels of confidence in the new measures described how they lacked understanding of how the measures operated. These participants typically noted that they had not received an explanation about how to use their new measures.

One participant explained how they were unsure how to change the settings on their heating system. This meant that they were turning it on or off rather than adjusting and customising heat settings for their property.

"I have not got the heat setting pre-set for day and night. I set them manually depending on the weather conditions outside and how cold/hot it feels in the house… I do not know how to change the settings even if I wanted to. I was not given any guidance on how to use the thermostat. This is why I choose to do it manually as it is what I know." – Resident (AppLife mobile diary research)

5.8 Exploring contribution

Overall, the model and evidence from resident research suggests that both WHR and SHDF(D) have led to reductions in energy consumption and carbon emissions for the properties retrofitted, and estimated savings were modelled to be highest for those properties that received clean heat measures. Only just over one third of residents (37%) reported energy bill savings in the survey, although resident perceptions of energy price changes should be interpreted with caution given the energy price rises experienced since 2022 and because pre-installation data collection with tenants was not possible.

As reported in the process evaluation,[71] the scheme contributed to high quality retrofits through application of the PAS2030/2035 process, as well as by encouraging installers to seek certification and register with TrustMark. Overall, there was a small increase in the ratings provided through stock assessment surveys which suggests that retrofits improved the general condition of most properties. However, research with residents undertaken for the outcome evaluation has shown that – in spite of the requirement to retrofit to PAS2030/2035, a few retrofits were not (yet) to this standard. A small proportion of residents with completed works (13%, n=19) stated they were dissatisfied with the overall impact the work has had on their property. This therefore suggests that the retrofits were to the anticipated quality in most, but not all cases.

[71] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

6. Outcomes for residents

This chapter presents analysis of how residents perceived the retrofits to have affected them.

Chapter 6 at a glance

Residents participating in research for this evaluation identified several benefits that they had perceived from the retrofits. These typically comprised improvements to how comfortable they felt in the home, the home aesthetics and subsequent effects on their health (mental and physical).

However, some residents also described some adverse changes in their experience of the home, which they considered to have resulted from the retrofit, or the retrofit process. These included detrimental effects on their health (mental and physical), new issues with the home arising post-retrofit, and a loss of space in the home.

The section brings together findings from a survey with 256 residents, 56 depth interviews with residents, site visits where retrofits were observed and – in some cases – residents were interviewed, lived experiences recounted by project teams and DESNZ as part of their learning and dissemination activities, and the results of the AppLife mobile diaries. It investigates evidence for the causal assumptions set out in the programme ToCs (see Figures 1 and 2 in chapter 3) that pertain to the health and well-being of residents, building aesthetics, and how residents use the home, including energy use and environmentally friendly behaviours. It also presents evidence of some of the adverse effects that the retrofit projects had on some residents. This chapter covers the following evaluation questions:

- Are occupants satisfied with the retrofits?
- How has resident behaviour changed post-retrofit?
- Are residents paying less on their energy bills post-retrofit?

6.1 How the schemes intended to create benefits for residents

Both the WHR and the SHDF(D) programmes were intended to provide benefits for residents. For both programmes, landlords were expected to engage and provide information to residents throughout the process, with the aim of ensuring resident satisfaction with the retrofit, both during the process and in the results. Additionally, it was expected that, through a programme of resident engagement, combined with the improvements in retrofitted homes, residents would be better able to use energy more efficiently in their home, thus supporting energy consumption and carbon emissions reductions. By increasing the air quality and comfort of homes through a reduction in instances of damp, draughts and mould, homes would be made

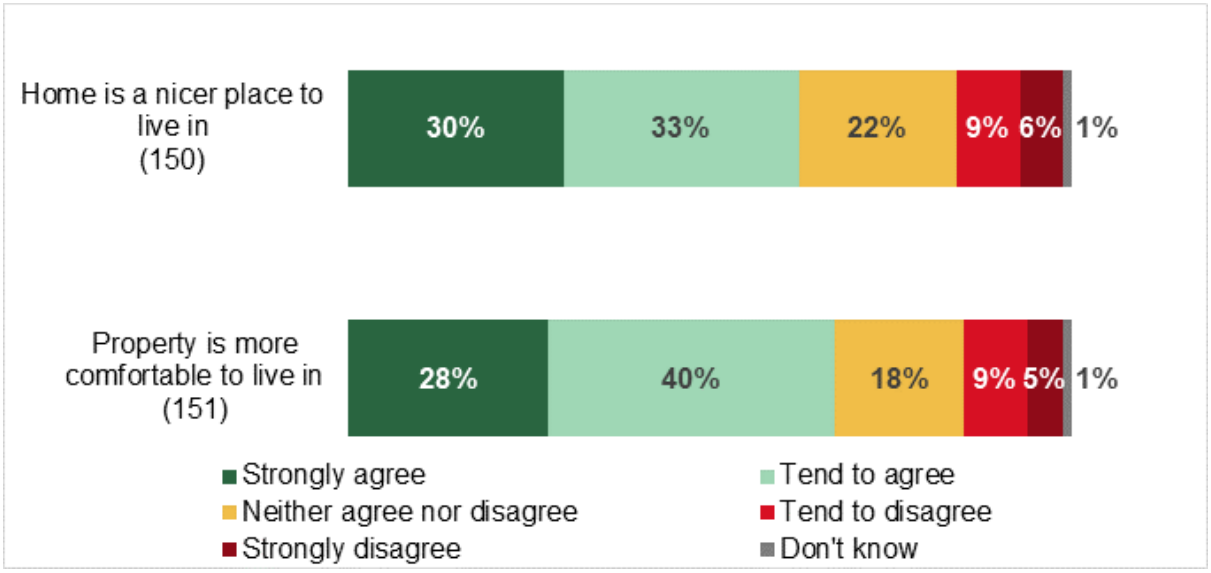
healthier contributing to resident wellbeing. It was also expected that, by increasing the durability of the treated homes, it would reduce the need for demolition and rebuilding of homes, thus saving on carbon emissions from new construction.

6.2 Evidence of changes in residents' experience in the home post retrofit

6.2.1 Changes in resident comfort in the home post-retrofit

Residents typically felt more comfortable in their home post completion of the works. Of those with work completed amongst resident survey participants, two-thirds agreed that 'my property is more comfortable to live in' and a similar proportion agreed that 'my home is a nicer place to live' (68% and 63% respectively).[72] In the qualitative research, residents said that their homes now felt warmer for longer. For example, some described that they no longer needed to wear extra clothing or use extra blankets in the winter months.

Figure 16: Reported perceived changes in the experience of the home



Source: Resident Survey, Q23 To what extent do you agree or disagree with the following statements in relation to the energy-efficiency work that has been installed in your property?

In qualitative interviews for this evaluation, residents reported changes in how they were using their homes, particularly rooms that had previously felt too cold. One resident noted they had turned their dining room, which was previously too cold to use, into an office and another resident noted that they were now able to sleep in their own bedroom whereas before it had been too cold for them to do so.

[72] Q23. To what extent do you agree or disagree with the following statements in relation to the energy-efficiency work that has been installed in your property? Base: all respondents answering with work completed. My property is more comfortable to live in (n=150), My home is a nicer place to live (n=151), It has had a positive impact on my mental health (n=149)

In some cases, residents noted that the works had changed the layout and functionality of their home, including having bigger windowsills where new windows had been installed, and more space, for example, where night storage heaters had been removed.

Where concerns were raised about levels of comfort, this was typically due to issues that had not been resolved by the works, such as draughts and cold spots, or where redecoration was required or snagging needed to be completed (see section 5.6 above).

6.2.2 Perceived improvements to health

Survey data shows some correlation between perceived improvements in health and wellbeing and whether the work had been completed, particularly in relation to the impact on mental health. Of those with works completed (n=149), one-third (33%) agreed that the work being complete had had 'a positive impact of their mental health'. However, in cases where the work had not been completed (n=75), only one in ten (11%) stated the retrofit was having a positive impact on their mental health with a significantly higher proportion of respondents (43%) saying it was not. (This is perhaps unsurprising as retrofits tend to be very disruptive even where steps are taken to mitigate disruption, which may generate stress for residents).

Where participants considered that the completed / near completed works had impacted on their mental health in interviews, they tended to consider the impact positive. Generally, there was a sense of relief that the works had been completed and the home was now a comfortable temperature. In the qualitative research (both depth-interviews and the AppLife mobile diary), residents reported fewer concerns or worries about putting the heating on, or the cost associated with the heating than pre-retrofit.

> *"[You feel] more happier in yourself walking in somewhere that's a comfortable temperature." – Resident (Interview)*

Whilst less frequently mentioned, some residents interviewed commented that works had positively impacted their physical health. In the resident survey, a third (33%, n=50) of respondents who had had retrofits completed agreed that it had had a positive impact on their physical health, with 14% disagreeing.

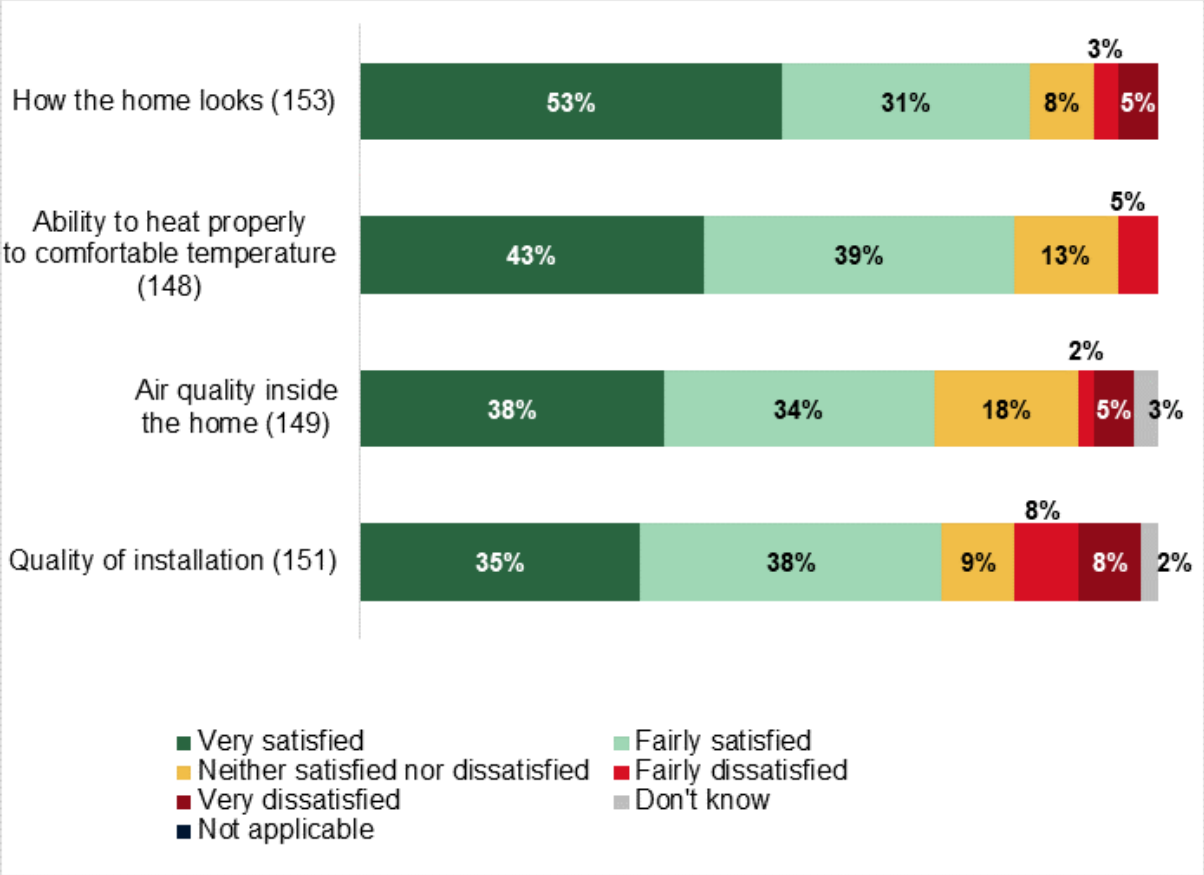
For example, one resident felt that they had experienced fewer cold-related illnesses since works had been completed. Where participants had pre-existing conditions such as respiratory concerns or illnesses exacerbated by the cold, they typically felt that their homes were warmer and that this had gone some way to helping to relieve symptoms.

> *"[My] wife suffers from rheumatism and the consistent heat was a benefit because she wasn't cold and not suffering from pain in the cold, it was a lot easier for her." – Resident (Interview)*

6.2.3 Changes in home aesthetics

Overall, survey participants were particularly pleased about how their home looked after work had been completed or was near to being completed. The survey found that 84% (n=128) of respondents who had had work completed stated they were satisfied with how the home looked post-retrofit (see Figure 17).[73]

Figure 17: Resident Survey Q20. Thinking about the energy-efficiency work that has been installed in your property, to what extent were you satisfied or dissatisfied with the following now it has been completed?



Residents participating in the qualitative interviews also described improvements to the outward appearance of their home. Residents were particularly satisfied with the external rendering, as well as the doors and windows that had been installed. In some cases, the perceived improved appearance of the home had made residents feel more positive about living in the property.

> *"When the scaffolding…came down, it made the house look like a showhouse." – Resident (Interview)*

[73] Q20. Thinking about the energy-efficiency work that has been installed in your property, to what extent were you satisfied or dissatisfied with the following now it has been completed? 'How your home looks' Base: all respondents answering (n=153)

Residents also fed back in interviews about how the inside of the home looked. This included positive views of how the home now looks, particularly where works had included the removal of storage heaters, old windows and pipe boxes, and the installation of new heaters alongside new plastering. Where mentioned, residents noted that the change gave their home a modern look and feel.

One resident described how they had been prompted to redecorate after the works and overall felt happier about their home.

> *"It looks like a home. We hadn't decorated in seven years... [But now works and redecoration are complete] we want to stay here. Before we were thinking about moving." – Resident (Interview)*

However, some said that they were still waiting for snagging or finishing touches to be completed which negatively affected aesthetics. This included painting and plastering needing to be fixed around new windows or holes or marks on the walls. Residents who reported this were less satisfied with the overall appearance of their home and some reported that they needed to redecorate, in order for their property to feel more like their home.

> *"I feel like I want to move out, they've made a right mess, it's not my house anymore… If you touch the wall, loads of stones come off [because they're] very loose. I have to decorate now, because the plaster has been a mess." – Resident (Interview)*

Mobile Diary Task (AppLife): Comfort in the home

Across the mobile diary task participants were asked to explain the types of measures they had had installed in their home and how these measures had made a difference to them – including their comfort levels and use of home.

One resident noted that due to the works in their home the resident was now able to use rooms in their home which were previously too cold to use in the winter, including their bedroom and the living room. In this instance, the participant had measures installed including internal and external wall and floor insulation, as well as a new heating system. Since the renovations were completed, the resident noted that they can now sleep comfortably in their own bedroom and spend time in the living room during the winter, because the home stays at a more comfortable temperature.

"This year me and my wife have actually slept in our own bedroom this winter. Although it has still been slightly cold, it wasn't as cold as it was… We have spent more time in the front room this winter than any other winters." – Resident (AppLife mobile diary research)

6.2.4 Changes to the local area and community

Some residents, as part of the qualitative interviews, gave the opinion that the improved outward appearance of the retrofitted homes had had a positive effect on the local area. They considered that the retrofits had made the area look tidier, more modern and maintained.

> *"With the houses being completed, it's spruced up the area a bit and generally makes it look nicer. Before the houses were looking a wee bit shabby. [The] upgrades have made it look nice." – Resident (Interview)*

However, other residents noted that, because not all houses or blocks of flats in the area had been retrofitted, there was lack of consistency in how homes looked which made the local area feel 'mismatched'.

> *"[It has] made the street look a little bit different, not everybody had it done. Looks a bit odd! Mine is done and hers [neighbour] isn't. Looks a bit mismatched. Would be nice if they were all similar." – Resident (Interview)*

Non-participating residents were not systematically consulted as part of the outcome evaluation. However, some participating residents interviewed during site visits or as part of the qualitative depths recalled discussions with neighbours where neighbours commented positively on their home. However, one participating resident described in interview how there had been queries amongst neighbours about why only certain homes in the area had been selected for works and this had created tension between neighbours.

> *"Not all the houses have had the works done, [and you] can certainly tell which ones have been, it highlights them." – Resident (Interview)*

6.2.5 Changes perceived by residents to their home's environmental impact

Whilst residents' views on the environmental benefits of the retrofits was not explicitly explored as part of the primary research, in most cases environment and climate benefits were not spontaneously mentioned as key outcomes by residents. In depth interviews and the AppLife mobile diary, participants more typically cited benefits related to warmer homes and reduced energy spend. Where environmental benefits, where cited, they were typically were secondary to these other outcomes.

> *"Benefit of reducing energy usage is my pocket, and the environment as well I suppose, especially in today's climate with bills." – Resident (Interview)*

Additionally, when recalling having received information about how to use measures in the home, participants did not mention receiving broader advice and guidance around having an energy efficient home. Although not a specific intention of either the SHDF(D) or WHR programmes, this could indicate a potential missed opportunity to engage residents about the impact of energy usage in the home, and more broadly steps energy consumers can take to meet Net Zero goals and reduce household emissions.

6.3 Evidence of adverse negative consequences of the retrofits for residents

This section presents some evidence of residents' perceptions of negative or adverse consequences resulting from the retrofits. It is important to note that the findings are not necessarily representative of residents' experiences within the SHDF(D) or WHR, as they were not collected from a representative sample of residents.

6.3.1 Loss of space in the home

Where residents considered that they had lost space in their home from the retrofit this was typically related to storage cupboards where equipment to support solar panels or new heating systems had been installed. The impact of this change varied. Whilst one participant reflected that it had not been a major inconvenience, another, who had since moved out of the retrofitted home, noted that changes would have been difficult with their mobility and reflected that it had contributed to their need to move to an alternative property. Additionally, measures such as internal wall insulation and loft insulation resulted in a loss of room space according to residents.

In some instances, residents also noted that they lost space during the works. For example, loft spaces had to be cleared for insulation to be installed, which then reduced the space in their loft. One participant described how they were renting storage space at additional cost, and another described being unable to store products they needed to work from home in their loft.

> *"They wanted to re-insulate my loft, but I have an eBay shop and all my stock was in my loft...They left me for a year where I couldn't work because my whole loft had to be emptied out." – Resident (Interview)*

6.4 Exploring contribution

Overall, where works were completed and outstanding issues resolved, the majority of residents expressed satisfaction with the measures implemented in their homes. This was particularly the case where the works had been completed smoothly and they had encountered few issues during the process. A common reason for their satisfaction was the improved warmth they experienced, as the homes were now able to maintain a more comfortable temperature and retain heat better than before.

There were also mentions of ways in which the home improvements had positively impacted overall wellbeing. These included residents feeling happier and more content with their living situation, which had a beneficial effect on their mental health. Reported improvements to physical health were more limited and typically focused on easing symptoms impacted by a cold home.

Generally, participants were satisfied with the improved appearance of their home. The survey found that over four in five residents with work complete were satisfied with how their home looks (84%, n = 128), with a significantly higher proportion being satisfied who had wall insulation (86%). This was also reflected in the qualitative research: those who had EWI and cladding added to their homes were particularly pleased with the appearance of the outside of their home. The improved appearance of the outside of homes also contributed to the improved appearance of the local area.

Positive engagement with residents and clear information provision played an important role in contributing towards residents' perceptions of benefits. Research suggests that to build satisfaction, any communications need to take into consideration how best to reflect any health conditions within resident households. There are examples of good practice, where residents felt supported during the works – wider consideration of this approach is likely to lead to improved resident satisfaction and avoidance of negative health consequences of works.

Information and guidance provided to residents about the measures installed in their home also plays a key role in supporting resident confidence in using measures, and more broadly their engagement in energy efficient behaviours. Effective information delivery includes the provision of guidance that goes beyond receiving manuals and provides demonstrations for how measures work. Future schemes could benefit from incorporating more formalised demonstrations of measures including making clear the link to energy efficiency to support resident understanding and encourage more energy efficient behaviours.

Overall, residents who had their properties retrofitted were satisfied with the results and perceived that they had received a range of benefits (comfort and warmth, health, aesthetics, local area and community) due to the retrofitting of their home. The research with residents has identified some instances of unintended negative effects of the retrofits. When considering the survey, resident interviews, and mobile diary evidence together, disbenefits of the retrofits appear to have been either minimal, anomalous, or outweighed by the perceived benefits of the retrofit.

7. Job and market outcomes

This chapter presents analysis of the extent to which the programmes supported jobs and the growth of the supply chain.

Chapter 7 at a glance

There is good evidence to suggest that the SHDF(D) and WHR programmes had a positive impact on retrofit market growth, by contributing to improved resilience within the retrofit market by increasing the employability for future retrofit projects for the companies involved.

The programmes also improved supply chain skills and understanding of technical retrofit skills and implementation. This was particularly driven in SHDF(D) by the requirement to apply PAS2035/2030 process. However, analysis did not find that the programmes contributed to significant supply chain development nor the maturing of innovative materials.

Participating companies struggled to deliver projects profitably. Despite this, companies interviewed, for the large part, reported that the experience gained outweighed any loss of profit, and that the market was growing. Market growth, in this case, was considered to be being driven predominantly by the subsequent waves of SHDF rather than the SHDF(D) and WHR programmes.

The programmes contributed to a modest increase in green jobs. However, the extremely limited supply of labour for both retrofit specific jobs and traditional construction jobs indicates that the net increase in green employment is likely to be limited.

This chapter addresses the following evaluation questions:

- To what extent did the programmes contribute to retrofit market growth?
- To what extent did the programmes support green jobs?[74]

To assess these questions, the evaluation took a contribution analysis (CA) approach. This theory-based approach assesses the causal pathways underpinning the outcomes and impacts highlighted in the programme ToCs (see Figures 1 and 2 in chapter 3). It is worth noting that these findings from project team and lead interviews of changes to customer base are largely self-reported. It was not possible to verify this with quantitative data, such as data

[74] This evaluation uses the UK HM Government's Green Jobs Taskforce definition of a green job as: employment in an activity that directly contributes to - or indirectly supports - the achievement of the UK's net zero emissions target and other environmental goals, such as
nature restoration and mitigation against climate risks. Accessed from :
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1003570/gjtf-report.pdf

on changes to revenue of employed firms. The evaluation team was also unable to assess data relating to business growth, given the small size of the companies employed on the programmes and the time lag on business reporting. This limited the extent to which a quantitative assessment of market growth, job creation and wider economic impact generated by the programmes could be provided. The Technical Annex provides more information on this.

7.1 How the schemes intended to support supply chain stability and growth, and jobs

It was assumed that WHR and SHDF(D) would support retrofit market growth because social housing landlords would have to employ companies to deliver the retrofit work, thereby increasing the market demand for retrofit. Research conducted through the process evaluation[75] indicated that the programmes could facilitate retrofit market growth by:

1. Increasing the size and resilience of the retrofit market.
2. Increasing the maturity of the technologies, and the skills, capability and capacity of the companies employed on the programmes.
3. Increasing willingness within the retrofit market to invest in whole house retrofit.

Underpinning the programmes was also an assumption that participation in WHR and SHDF(D) would support green jobs because, to deliver the works to a sufficient standard, participating social housing landlords and companies employed on the programme would need to employ people in green jobs thus increasing their skills and capabilities in green sectors.

Given these hypotheses, the evaluation team dissected each one into 'contribution claims' i.e. statements defining how the programmes were expected to enable outcome realisation. The team then tested each contribution claim, and alternative hypothesis, by triangulating the findings from each of the data sources and assessing the strength of evidence. The CA steps and contribution claims are presented in detail in the Technical Annex.

7.2 Changes in the size and resilience of the retrofit market

As set out in the programme ToCs, it was anticipated that the SHDF(D) and WHR programmes could increase resilience in the retrofit market by increasing the stability[76] of companies employed on the programmes. The programmes could do so by increasing companies' customer base: increasing the number or size of retrofit projects the companies deliver

[75] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.
[76] Where a company's 'stability' is their ability to maintain a steady and consistent performance over time, such as in financial standing, market share, revenue, or operational efficiency.

following participation in the programmes. Participation in the programmes could add to companies' track record of delivering retrofit projects, increases their reach and improving their reputation. This would lead to an improved ability to attract a sustained pipeline of future retrofit work. This would increase market resilience by providing greater revenue stability to these companies. It was also hypothesised that the programmes could provide market resilience by providing companies with income during the economic shock due to COVID-19, which would have otherwise not been available. The validity of this hypothesis was tested using the data collected; the findings from which are detailed below.

7.2.1 Increasing customer base

The hypothesis that participation in the programme led to an increase in customer base is broadly supported across the evidence strands.

Members of project teams indicated in interview that participation in the programme frequently led to an increase in future work: retrofit installers and contractors commented that their participation in the programmes had helped "cement partnerships" with local authorities and housing associations for SHDF Wave 1 and/or Wave 2.1 successor projects and other future retrofit projects. Similarly, project lead interviews indicated that the programmes were beneficial for developing relationships between social housing landlords and primary contractors. Many companies also indicated that the programmes led to an improvement in their companies' reputation for delivering retrofit. This was consistent across a range of different sizes and types of companies, including small scale retrofit coordinators, large primary contractors, and design partners.

Some suppliers that had implemented SHDF(D) projects indicated that participation had enabled them to showcase examples of delivery of PAS2035/2030 compliant retrofit. This has been used to evidence the effectiveness of their products and improve their reputation as a supplier of retrofits, which led to an increase in involvement with ongoing waves of SHDF.

> *"…I think for us it has definitely established our reputation and our brand and built very strong working relationships with companies, large companies, which we would have struggled to do if we didn't have the [SHDF] demonstrator." – Supplier/Installer, SHDF(D)*

However, a subset of companies interviewed for the project teams' interviews indicated that participation in the programmes did not lead to an increase in follow-up work. These companies were predominantly involved in the WHR programme and provided whole house retrofit services. These respondents cited the lack of follow-up work because of the scope reduction for the subsequent waves of SHDF. This meant that these providers of "deep retrofit" were no longer required.

In preparing the framework for the contribution analysis, the evaluation team hypothesised that for participation in the project to lead to a sustained increase in customer base, it would require that projects were successful in achieving their objectives. This would lead to an improved

reputation for delivering retrofit in the market, improving their ability to win future work. This included achieving sufficient scale, energy demand and cost reduction. However, whilst the majority of projects did achieve energy, carbon and bill savings per property (see chapter 5), project reporting indicates that the majority of projects failed to achieve their other key objectives.

Project teams interviewed indicated that, whilst they experienced delivery challenges, the experience of delivering the whole house retrofit approach as part of these programmes nevertheless improved their reputation as a provider of retrofit services. This could be due to the relatively novel nature of whole house retrofit meaning that there is a relatively small pool of companies with experience of delivering these services.

7.2.2 Stability in the face of the economic shock of COVID-19

The SHDF(D) programme was implemented in December 2020, as part of the Government's wider £3 billion COVID-19 Green Economic Stimulus package. The stimulus package portfolio consisted of four programmes,[77] which collectively aimed to support post-COVID-19 pandemic recovery by supporting companies and jobs in the (green) retrofit and construction sectors. The SHDF(D) ToC conveys a hypothesis that companies participating in the programme would be more resilient to the potential business-level and macro-level economic shocks of COVID-19, because the funding from the programmes (and any knock-on effects) would provide them with a steady source of income and certainty during the post-COVID-19 period.

Responses in the project teams interviews were mixed as to the effect of the programmes in providing stability through COVID-19.

The majority of companies that were involved during installation (including primary contractors and installers) and interviewed for the evaluation indicated that the revenue provided by the programmes was not significantly important in providing their company with income stability during the economic shock. The delay in project delivery across the programmes meant that the bulk of installation across the programmes was underway in 2022, after the highest intensity periods of the pandemic.

> *"…It [employment on SHDF(D)] was slightly after, to be honest. So, we only started this properly late last year, so obviously it was well outside really, the COVID-19 period. So, no I wouldn't say it really had any impact." – Contractor, SHDF(D)*

However, some companies interviewed indicated that the project was important in providing income during a period of uncertainty. This was more likely to be reported by companies involved in earlier stages of delivery, such as in the design and pre-installation phases. This includes design consultants, architects and some primary contractors, such as those on

[77] The Green Homes Grant Vouchers Scheme (GHGVS), the Green Homes Grant Local Authority Delivery Scheme (GHG-LAD, the Public Sector Decarbonisation Scheme (PSDS) and the Social Housing Decarbonisation Fund (Demonstrator) (SHDF(D)).

Design-and-Build contracts[78] who were involved in either surveying activities or design elements.

A similar story was found for the impact of the programmes on the retention of workers through COVID-19. The majority of project team respondents indicated that they did not see their involvement in the SHDF(D) programme as particularly important for retention of workers. Reasons provided were similar to those outlined above, with most indicating that they were involved after COVID-19 lockdowns had broadly ceased. Our sample of project teams unfortunately did not contain any representatives for companies employed on the WHR programme during either the initial lockdown (March 2020) or second lockdown (November 2020).

7.3 Capacity to deliver retrofits

As per the programme ToCs, the SHDF(D) and WHR programmes were expected to build companies' capacity to deliver retrofit, either by providing an opportunity for participating organisations to improve their skills, or by providing an opportunity for companies to mature their technologies. An assessment was made on the extent to which programme funding for skills development, the requirement of PAS2035/2030 compliance and the technical assistance provided by DESNZ (which includes guidance, resources for support and learning opportunities), contributed to capacity building and skills development for the companies involved. An assessment was also made on the extent to which the innovative technologies and services deployed were developed during project delivery.

For the second evaluation question, the evaluation team hypothesised that a particularly important facet of the programmes supporting green jobs would be through the development of retrofit-specific skills. This would improve workers ability to work in green roles and improve their transferability to other green positions. This would apply to both workers who are already in green roles and those pivoting from other industries.

7.3.1 Skills development

Evidence from the project team interviews supports the hypothesis that participation in the programme facilitated skills development.

Interview participants indicated that the programmes provided the opportunity to develop their retrofit capabilities. Several interviewees indicated that they, and other members of their team, had undertaken retrofit specific training courses during or prior to delivery of their project. This included undertaking training on understanding domestic retrofit, and specific training to become retrofit coordinators and air source heat pump installers. It was cited that training opportunities provided the opportunity for the development of technical skills for whole house

[78] A Design-and-Build contract refers to a construction project where there is a sole provider of both design and construction services, rather than having separate contractors.

retrofit. Project leads also provided positive evidence of upskilling in the client organisation (LA or housing association) during project delivery.

> *"…without this [the SHDF(D) programme], we wouldn't be in a position where we're starting to develop some really highly skilled people that are going to be able to deliver some really good projects into the future." – Retrofit Coordinator, SHDF(D)*

However, project team interviews did not provide conclusive evidence of the additionality of the programmes on skills development. For example, multiple respondents indicated their companies' investment into retrofit skills was in response to wider market shifts towards retrofit. Respondents indicated that the pipeline of future government-funded retrofit projects was the driving factor behind their ongoing upskilling. In addition, one project team member indicated that training undertaken was part of their companies annual training schedule and was not influenced by participation in the SHDF(D) programme.

The majority of companies interviewed in the sample indicated that they had previous experience in retrofit, with a smaller proportion indicating they had limited experience. For companies with previous experience in retrofit, project team members were less likely to consider that participation in the programmes had impacted positively on skills. The most cited reason for a lack of skills development was that the company already had the skills in-house. This was predominantly reported by companies where retrofit constituted a particularly large proportion of their offering, such as design firms specialising in retrofit, installers of heat pumps or largescale primary contractors with a significant history of delivering retrofit.

> *"I don't think it's had a lasting effect in terms of the jobs and the skills because we already had the skills to deliver each of the elements anyway. But fundamentally, this was a fantastic pilot project for us as a business to deliver end to end... I think it [the project] demonstrated to us as a business in terms of how we can deliver in sequence, multi-measures to a property and there's quite a coordination involved with various aspects." – Primary Contractor, SHDF(D)*

However, companies interviewed that indicated that they had limited previous experience of delivering retrofit projects, saw employment in the project as enabling them to transfer their traditional construction skills to retrofit specific processes. For example, using skills in installing traditional loft insulation to installing EWI to PAS2035/2030 standard. Respondents indicated that whilst they had previous experience in refurbishment on social housing, the project in which they were employed was their first involvement in a PAS2035/2030 compliant retrofit project. This was corroborated in the project lead interviews, who indicated that a significant proportion of contractors employed had limited retrofit experience. Companies interviewed also described how, through the retrofit projects, they improved their capabilities in project management, client liaison skills and understanding of the processes involved in delivering a large scale retrofit project.

> *"…that [the SHDF(D) programme] has now increased our resource capability, and I think it's definitely developed the skills operationally and the client liaison skills dealing with many contractors and councils and social housing providers." – Supplier/Installer, SHDF(D)*

Other project team members considered that the programmes' effects on skills and capabilities development was limited due to the programmes' anticipated short delivery window, which created a barrier for some companies to invest in long-term training opportunities. Companies referred to "short term upskilling" as taking precedence over longer term skills development. One project lead indicated that the short timeframe for delivery meant that the organisation could not implement initiatives such as building long-term apprenticeship programmes.

The evaluation lacked sufficient evidence from the qualitative data strands and the monitoring data to be able to robustly assess the impact of the technical assistance provided by DESNZ on skills development and capacity building.

7.3.2 PAS2035/2030

A salient finding from the project teams' interviews was that teams perceived PAS2035/2030 compliance to have had a positive effect on improving the capacity and capabilities of employed companies. This was because of two factors: it incentivised contractors to become PAS2035/2030 accredited, and it (subsequently) improved their understanding of the implementation and management of a PAS2035/2030 compliant retrofit project. Both factors contributed to an increase in the capacity of employed companies to deliver largescale retrofit projects.

Many respondents for both project lead and team interviews indicated that they had become PAS2035/2030 accredited during, or immediately before, participation in the programme. Interviewees indicated that compliance to PAS2035/2030 needed a "higher skill set" compared to delivering on other retrofit projects or other construction work. Project leads also reported positively on the fact that they had been upskilled on PAS2035/2030, with it leading to an increase in the number of people taking on skilled roles. However, there was evidence that some social housing landlords and primary contractors outsourced retrofit specific roles to external providers rather than developing their in-house capacity. In these cases, the extent of skills development because of the requirement for PAS2035/2030 compliance is likely to have been reduced.

> *"…as a result of the job, we achieved our accreditation and four other installers got their PAS2035/2030 accreditation and suppose, they maybe wouldn't have done it if it wasn't for this demonstrator. That is the catalyst really, which is a good thing." – Primary Contractor, SHDF(D)*

A large proportion of respondents in both interview strands consistently referred to gaining an improved understanding of not only the technical skills required, but also the implementation and management of a PAS2035/2030 compliant project. One respondent stated that

PAS2035/2030 was an “eye-opener” in terms of its requirements across the entire project delivery. For some, improved understanding of the implementation of PAS2035/2030 was seen as more salient a learning than the technical skills. Project teams indicated that this was due to the relative applicability of traditional construction skills to retrofit skills, whereas a majority of respondents did not have experience in management of largescale PAS2035/2030 compliant retrofit projects.

> *“…I spent quite a bit of time getting my head around the PAS2035/2030 standard that we were working to. In terms of the skills for the retrofit design itself, we had those skills already, but it was more about the mechanisms of the PAS that we were upskilling on.” – Architect, SHDF(D)*

7.3.3 The maturation of innovative materials and services

One of the ways through which WHR and SHDF(D) expected projects to be able to deliver whole house retrofit at scale and at a reduced cost was through innovation. As set out in the process evaluation,[79] projects utilised technological innovation, process innovation and solutions innovation. Some projects had aims to trial, demonstrate and/or mature their application of technologies. This was particularly the case for WHR, which was designed with the deployment of innovative materials as a key objective. For example, the Energiesprong Sutton project set out to deploy "porch pod” energy modules: a novel heating system solution that brought together renewable heating, hot water and ventilation technology and housed the ‘kit’ within a modular external porch (meaning space would not have to be found within the property to house the technology).

However, data gathered through interviews with project team members and final project reporting suggest that the programmes did not significantly contribute to a maturing of the technologies and innovative services deployed. This was due to the small scale of properties treated, the lack of project success in deployment and lack of security. Project leads indicated that the supply chain for retrofit materials was underdeveloped, and the programmes did not lead to a significant change in supply chain readiness.

For Energiesprong Sutton, monitoring data indicates that there were significant issues with the functioning of the heat-pump technology within the “porch pod” deployed in their second phase of delivery, with residents complaining that they were not producing any hot water or heating. This led to the decision to switch manufacturers of the technology for the final phase of delivery. Whilst this provides evidence that the initial technology was unable to be successfully deployed at scale, we are unable to comment on whether this acted as a learning opportunity for the manufacturer – leading to the improvement of the products and services offered – given that this specific manufacturer was not interviewed as part of this analysis. Deployment of the alternative technology in the third phase of delivery subsequently also faced delays due to issues with obtaining planning permission. This exemplifies how successful delivery of

[79] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

innovative technologies is also contingent on factors such as planning and project management.

For off-site assembled EWI, project team members across the projects indicated that there was limited development of this technology during project delivery due to the programmes' short delivery window. To deploy this technology, manufacturers cited needing a significant pipeline of future work to stimulate investment in infrastructure. However, respondents indicated that the change in focus away from whole house retrofit for SHDF Wave 1 and 2.1 has limited the pipeline of funding available to deploy this technology and therefore has limited subsequent supply chain development. Others also felt that this change in scope was "discouraging" as it limited the opportunity for projects to deploy innovative approaches on future waves to facilitate infrastructure building.

> *"…we've identified a couple of manufacturers of those integrated off-site solutions during the process…they need a secure pipeline and they need scale. So, year-to-year funding schemes just don't work, basically, because there's not enough certainty for either the housing provider or the manufacturer to invest in the processes and manufacturing facilities to bring the costs down." – Consultancy, WHR*

7.4 Market outlook

A third hypothesis underpinning the ToCs is that the programmes could contribute to retrofit market growth by showcasing the profitability and market potential of delivering retrofit projects to retrofit providers, installers, and associated businesses. This would then incentivise companies within the wider industry to shift towards delivering retrofit projects, and to therefore invest in their capabilities to deliver future projects. An assessment was made on the extent to which this materialised, by asking project team members about the profitability of the projects, and their outlook for future involvement in retrofit projects. The viability of whole house retrofit as an approach for those companies involved was also investigated. This assessment also included the analysis of alternative explanations as to why companies were investing in their potential to deliver retrofit and entering the sector, including alternative funding streams and growth in other sectors.

7.4.1 Evidencing profitability

The data analysed indicates that the majority of companies across the programmes failed to achieve profitable delivery.

Project team interviews indicate that a large proportion of companies experienced high costs, challenges in delivery and limited profitability, with a significant proportion of respondents indicating the project made a loss. The majority of project team interviewees reported significant increases in the costs for materials and labour, mainly due to the increased

inflationary pressures present in both the construction sector and the wider market since 2020. Project leads also indicated that costs experienced in delivery were significant.

> *"I think if everyone understands that it was an absolutely excellent learning curve, then yes, it was profitable, but if we're talking about finances, no one was profitable from it." – Contractor, SHDF(D)*

In addition, interview evidence suggests a perception from those involved in delivery, that the programmes themselves generated some cost increases in the retrofit market. One respondent indicated that the SHDF(D) programme caused an "over-heating" of the labour market, with the large amount of funding and the limited supply of labour available. This contributed to price increases in labour and material resources within the retrofit sector. This finding was also corroborated during a site visit, with a project team member similarly indicating the cost impact of the accredited labour shortage. However, respondents did indicate that this impact was likely to be relatively short-lived as the industry settles.

> *"…I would say a shortage of PAS-accredited suppliers, which we're mandated to deliver, which means that you've got a very restricted supply chain to go to, and that creates its own pressures…By limiting the supply chain, you actually drive some inflationary pressure into that marketplace, so that's then impacting the delivery." – Property Service Company, SHDF(D)*

However, not all companies who were employed on the projects, delivered a loss. Across research strands, respondents noted that the requirement for PAS2035/2030 compliance led to a severe shortage of accredited labour available. This led to some companies and individual subcontractors being able to charge prices that were significantly higher than non-accredited counterparts. There was also evidence that some suppliers were able to charge high prices due to the lack of alternatives available in the market.

7.4.2 The pipeline of future work

Whilst the profitability of delivery of the SHDF(D) and WHR programmes was limited, companies widely reported a positive market outlook. Project teams extensively reported that they were continuing to invest in their potential to deliver retrofit. This was cited as being because of the continued pipeline of work with the ongoing waves of the SHDF and other retrofit projects implemented. Project team members indicated that there is now greater visibility of the market trajectory, which has enabled an improved ability to plan and invest in potential to deliver retrofit. Interviewees indicated that in previous years, companies were disincentivised to dedicate investment towards retrofit given the "stop-start" nature of government investment in retrofit projects. Companies indicated that they were actively investing in their retrofit ability, such as by bringing on in-house retrofit coordinators and designers and investing in retrofit specific training.

> *"…for us, having that visibility, having the size of funding that that's been provided into the sector through schemes such as SHDF has allowed us really to have the confidence to invest in the business." – Wider Retrofit Market Stakeholder*

Project teams indicated that they believed that the market was growing, with more companies entering the market and pivoting their offering to have a greater focus on retrofit. Respondents indicated that there has been significant revenue growth within the sector over the last two years. For the most part, this was attributed to wider movements towards retrofit in line with the government's Net Zero targets, rather than a direct result of the SHDF(D).

> *"… I think we have seen capacity growth from the demonstrator … But I think that's only going to grow further through the more pipeline that they can see in front, the better able they are to build capacity to deliver it." – Primary Contractor, SHDF(D)*

> *"As a business we've noticed revenues going up in the work we've done in retrofit. I would say it's not the most profitable work we do because of how much time it takes, there's a lot of hand holding, yes, I think if the retrofit industry sticks as it is and people get slicker and better at it then they'll improve for everybody there including themselves."* – Wider Retrofit Market Stakeholder

Interviews with wider retrofit market stakeholders also indicated that the pipeline of work has motivated companies to invest in their capacity to deliver retrofit. However, for the most part these interviews did not provide a distinction between the SHDF(D) and subsequent waves of the SHDF, limiting the extent to which this increase can be attributed to the impact of the SHDF(D) programme.

> *"Having the size of funding that's been provided into the sector through schemes such as SHDF has allowed us to have the confidence to invest in the business." – Wider Retrofit Market Stakeholder*

7.5 Supporting green jobs

It was anticipated that the programmes would support green jobs through two key means: increasing employment in green jobs and developing skills that would better equip workers to fulfil their responsibilities in green roles. The programmes had a positive impact on skills development (full details provided in section 7.3.1). However, the evidence indicates that the programmes have not generated or sustained green jobs at scale.

It was hypothesised that both the companies employed on the programmes and project lead organisations would need to bring on more staff to deliver the retrofit works to complete the projects. This would therefore lead to the creation of green jobs and an increase in green employment.

However, project team interviews gave a mixed response as to the extent to which involvement in the SHDF(D) and WHR programmes led to an increase in employment within their company.

In the instances where companies reported positive job creation, this was usually relatively modest. These companies were varied in size, including large nationwide construction companies and smaller retrofit installers. The companies reporting the largest increases in employment were small scale surveyors and providers of retrofit coordinators. However, it was difficult to disentangle the impact of the SHDF(D) and WHR programmes directly compared to wider changes in the retrofit market. It is also likely that some of the reported employment increases were instead because of involvement in SHDF projects.

Project team members interviewed frequently either did not provide any evidence of job creation or indicated that they did not bring on any additional staff during project delivery. Architects and consultancies were less likely to report employment increases, with one reporting that this was due to the project being "relatively small for the practice". Despite this lack of an increase in employment, no company interviewed indicated that they had reduced their staff numbers during project delivery.

Employment data from publicly available Companies House accounts[80] for the companies who participated in SHDF(D) and WHR[81] does not provide a clear picture of any notable increase in total employment. On average, participating companies saw a 14% increase in total employment over the period of 2019 to 2021 (latest available data). Whilst this suggests that total employment was increasing, it does not provide evidence of the attribution of job creation to WHR and SHDF(D) – the increases could have been due to many different drivers over the time period concerned. It is also worth noting that given the large delays in delivery, the majority of installations did not commence until 2022, limiting data coverage for companies involved in the installation phase. Furthermore, the average number of employees across all companies within the dataset is affected by four companies with over 1,000 employees. When these companies are excluded, the change in average employment was negative – a 6% reduction.

It was hypothesised that for the programmes to lead to green job creation, employment would have to be sustained after contract completion. This could either be through pivoting to a new green role within the organisation or working in the same capacity on subsequent retrofit projects.

The project teams' interviews found that this was largely the case for respondents who indicated a positive increase in employment. This was particularly the case for retrofit coordinators, given their reported lack of supply across the market. This was not the case for all roles across the programmes, with one company indicating that a Resident Liaison Officer's

[80] https://www.gov.uk/government/organisations/companies-house

[81] This was based on the list of companies provided by projects in final reporting, which included design partners, project management entities and installers. Given that this was self-reported, researchers were unable to verify whether this sample was complete. In addition, researchers had to remove a small number of companies from the sample due to lack of available data.

(RLO) role was not sustained after contract completion. The respondent indicated that RLOs are generally more restricted to a smaller geography and are less likely to travel compared to other retrofit roles. However, the evaluation team was unable to verify the findings of the project team interviews on the sustainability of green jobs with either project lead interviews, monitoring data or external secondary data.

7.5.1 Net increase in employment in green jobs

Green job creation on the programmes would only be a net increase in green employment if there was surplus in the labour market for retrofit specific roles, accompanied by a shift of workers from non-green construction industries. For example, there would be no net increase if projects were recruiting workers for green jobs from other green roles (in either alternative retrofit programmes or other energy efficiency programmes). Therefore, the evaluation team tested whether there was surplus in the labour market for retrofit specific market roles and the extent to which programmes recruited from traditional construction sectors. The team found that there was limited surplus in the labour market for retrofit specific roles, with an insufficient quantity of workers recruited from non-green industries.

Across research strands, evidence suggests that there was significantly limited supply of labour for retrofit specific roles. Project team members reported challenges in recruiting for both retrofit specific and more general construction roles. A significant number of companies reported issues in recruiting retrofit coordinators due to the limited number of number available in the marketplace. For other companies, they felt that while there were enough retrofit coordinators in the market, the number with enough experience, or the necessary understanding of project management for construction to effectively coordinate a largescale retrofit project, was limited. Smaller sized companies also reported difficulties in securing and retaining skilled workers given the large number of schemes implementing whole house retrofit. Interviews with wider market stakeholders supported this, indicating that there is limited capacity within wider industry to support the onward delivery of retrofit programmes.

> *“There's also been real challenges in organisations like ourselves in terms of retention and recruitment, because there's so much work out there, so to speak, just using local authorities as an example, and the whole retrofit approach… they're [local authorities] looking to recruit and sometimes that recruitment could be taking skilled workforce from other similar organisations as well.” – Primary Contractor, SHDF(D)*

In addition, primary contractors and management agencies who participated in SHDF(D) reported a lack of PAS2035/2030 accredited installers in the market, which created issues for project delivery. Some believed that whilst there was available labour in the market for certain tasks, such as installing loft insulation, this could not be accessed due to them lacking accreditation. They saw this as creating inefficiencies, further exacerbating delivery challenges, and increasing the cost of accredited labour. This finding was also reported by project leads. However, interviewees across research strands indicated that some of the issues with the

supply of accredited installers and associated high costs is likely as a result of the retrofit industry being in its infancy, and these issues are likely to diminish with industry development.

> *"…it was clear from the market that there were limited resources within the market. And there were definitely some resources leaving site, for example, for better opportunities elsewhere, because they were in such short supply and in such high demand that price dictated where they worked, to a degree." Property Service Company, SHDF(D)*

For recruitment from other industries, interviews with project leads and teams indicated that whilst many project team members did not have significant retrofit experience prior to project commencement, this did not constitute the necessary shift away from non-green industries to cover the demand for labour. Interviews with wider market stakeholders also highlighted the lack of incentives for some installers and small-scale construction companies to become PAS2035/2030 accredited when they can deliver higher profits with greater ease in other sectors. For example, new build projects are generally easier to deliver and encounter fewer delivery challenges than PAS2035/2030 retrofit projects as the residents are not in-situ, there is often less remedial work required, and there are simpler project management processes.

> *"…the problem is attracting people into the Retrofit industry and I think there's two issues with that. One is that the building industry still isn't really a very attractive industry to attract school leavers … and so there's a whole issue with how do we get people into an industry which needs to probably double its capacity. And then the other is why would they go into retrofit rather than new build?" - Wider Retrofit Market Stakeholder*

In addition, companies reported wider labour shortages in the supply of traditional construction roles, including project managers, installers, and electricians. Interviewees identified that this was mainly caused by the impact of Brexit, and the increase in the number of construction projects operating simultaneously post-COVID-19. Several project team members also reported geographical issues. This was not only cited for projects that were in isolated geographies, but also for those within a relatively proximity to large urban areas offering more attractive pay.

> *"…It has always been a problem, recruiting… Then at the time-, I think it was the time of Brexit…so… I know a lot of the EWI contractors are quite foreign labour intensive as well. I know a lot of the supply chain we spoke to…had a reduction of their labour resource at that time." Project Manager, SHDF(D)*

7.6 Exploring contribution

Evidence suggests that SHDF(D) and WHR programmes had a relatively positive impact on retrofit market growth, predominantly through the impact on improved resilience.

The programmes contributed to improved resilience within the retrofit market by increasing the ability of companies' to be employed on future retrofit projects. The programmes also facilitated capacity building for the companies employed by improving their skills and understanding of technical retrofit skills and implementation. This was in particular driven by the requirement to deliver in compliance with PAS2035/2030.

However, the programmes did not lead to significant supply chain development nor the maturing of innovative materials. Employed companies also struggled to deliver projects profitably. Despite this, companies interviewed were, for the large part, investing in their ability to deliver retrofit and reporting that the market was growing. Market growth, in this case, was considered to be being driven predominantly through the subsequent waves of SHDF rather than the SHDF(D) and WHR programmes.

The main facet through which the programmes supported green jobs was through the development of skills for workers across both the companies employed on the project and within the local authorities leading the projects. The programmes contributed to a modest increase in green jobs. However, the extremely limited supply of labour for both retrofit specific jobs and traditional construction jobs indicates that the net increase in green employment is likely to be limited.

Table 8: Evaluation question assessment

Hypotheses tested	Assessment	Strength of evidence	Triangulation
The SHDF(D) and WHR programmes contributed to retrofit market growth	Supported	Medium	Y
The SHDF(D) and WHR programmes supported green jobs	Partially supported	Medium	Y

8. Cost Reduction

This chapter assesses the cost reduction outcomes for both the WHR and SHDF(D) programmes.

Chapter 8 at a glance

Based on the data available, only a small minority of projects achieved cost reductions. A key barrier to cost reduction was the inflationary context at the time of projects delivery which drove significant cost increases for construction materials.

Cost pressures were exacerbated in these programmes due to the lack of specialist suppliers and installers, in particular for SHDF(D) which had the extra requirement of requiring PAS2035/2030 compliance.

Key strategies for cost management included: value engineering to determine the most effective set of measures for the cost; reducing the number of measures installed; and in some cases reducing the number of properties being retrofitted. Cheaper materials were also used to bring down costs.

However, the lack of observed cost reductions does not necessarily invalidate the hypothesis that at scale retrofit and innovation in applying whole house retrofit can lead to a reduced cost per property of the whole house retrofit method.

The chapter focuses on the following evaluation question:

- Have cost reductions for retrofit been achieved and – if so - how?

Neither the WHR nor the SHDF(D) programme provided a definition of cost reduction, nor specified how cost reductions should be calculated. However, in their funding application forms (for both programmes) projects were required to provide an indication of (a) their cost reduction strategies (process, solutions and/or technological innovations), and (b) their 'baseline costs' – i.e. what they would expect the per property and overall cost of retrofit to be in the absence of the cost reduction strategy. For the purposes of this evaluation, cost reduction has been defined as set out in Box 1.

Box 1. Cost reduction definition

Projects can claim to have reduced the baseline costs of their project in line with the objectives of WHR and SHDF(D) where all of the following apply:

- The project provided baseline costs in their proposal / application form (against which they are claiming to have achieved a reduction) which were:
    - evidenced in the proposal,

    - were independently verifiable, and
    - were assessed as accurate and/or plausible by the evaluation team.
- The estimated final cost of the project (and cost per retrofit) in the proposal / application form is 5-20% less than the baseline costs (WHR) or 5-30% less (SHDF(D)).
- Post-construction or at project closure, the project has remained within the budget set at the outset of the programme (i.e. there has been no increase in DESNZ funding nor match funding).
- The project has not significantly reduced its scope either through a reduction in properties retrofitted, (types of) measures installed, and/or sites covered.

This definition assumes that the project encounters very few or no unanticipated delivery challenges, and/or it is able to address these challenges with very little or no adaptations to project budget and/or scope.

In addition, projects can also claim to have reduced costs where they have:

- Increased their budget from the one originally in their application, and/or
- Significantly reduced the scope of the project, but
- When considering the scale of cost increases faced due to unanticipated delivery challenges, they have been able to keep project costs (5-20% or 5-30%) lower than could have been the case if they had not implemented process, solutions and/or technological innovations.

This chapter explores both definitions of cost reduction and the extent to which projects achieved either one or neither of these.

8.1 How the schemes intended to achieve cost reduction

A primary objective of both the WHR and SHDF(D) programmes was to test whether deep retrofit ('whole house retrofit') projects could be implemented at a reduced cost through economies of scale and innovation. That cost reductions could be achieved was informed, in the case of both programmes, by qualitative research commissioned in 2017 by BEIS in which installers and contractors gave this view.[82] The research found that this might be achieved through the scaling up the number of dwellings retrofitted in a single project, with further reductions being achieved through process innovation and the co-benefits of the "learning by doing" approach.[83] WHR set an objective for projects to achieve a 5-20% reduction against

[82] BEIS (2017) 'What does it Cost to Retrofit Homes? Updating the Cost Assumptions for BEIS' Energy Efficiency Modelling'.
[83] WHR and SHDF(D) Competition Guidance

baseline costs, and SHDF(D) set an objective for projects to achieve a cost reduction target of 5-30%.

Projects employed a range of approaches to try to deliver cost reductions, as outlined in project applications, interim reporting, and in the learning communities, and discussed in the process evaluation of WHR and SHDF(D),[84] as well as in this chapter. As per the WHR competition guidance, WHR-funded projects were expected to deliver cost reductions through a combination of economies of scale, design replication and procurement, technology, and installation innovations. The SHDF(D) grant competition was less prescriptive on the cost reduction strategies that projects could implement, but, in their application forms, project teams set out strategies such as bulk purchasing, off site manufacturing, more efficient use of labour, improved design, and better process management.

Table 9 sets out the cost reductions anticipated in applications from the 16 WHR and SHDF(D) projects.

[84] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

Table 9: Baseline cost of retrofit per property (average), target cost and cost reduction strategy (at application stage)

Project	Baseline costs (without strategies applied)	Cost reduction target	Estimated cost reduction	Strategy
SHDF(D)				
Alva Community Regeneration through Decarbonisation	£51,858	£48,296	9.1%	Pre-tender piloting (to understand costs), reducing overheads, no. days contractors on site and scaffolding hire costs through 'in stereo' retrofit.
Clarion Housing Group Advanced Retrofit Project	£54,000	£48,600	10%	Incremental improvement and construction process optimisation, innovative procurement.
DORIC	51,000	£46,127	>10%	Smart work scheduling to reduce stand-still contracting losses, procurement approach ('procurement challenge').
Destination Zero II	£72,817	£52,566	40%	Offsite manufacture, economies of scale in procurement from Mauer, technology (Q-bot), just-in-time works, process improvement.
Gloucestershire SHARe and CaRe Demonstrator	£39,729	£37,743 - £27,811	5-30%	Passivhaus Planning Package modelling, streamlined data collection, real-time lesson learning.
Leeds Whole House Retrofit	£40,700	£28,490	30%	Property piloting, use of ENGIE's local supply chain, group and nationally agreed discounts and supply chain engagement strategies that mitigate risk, bulk

Project	Baseline costs (without strategies applied)	Cost reduction target	Estimated cost reduction	Strategy
				purchasing, having properties retrofitted in close proximity and the area well-managed.
National Net Zero Retrofit Accelerator	£85,000	£70,000	18%	Through 'at scale' model developed by Energiesprong, through innovation, knowledge-sharing and real-time learning.
Northampton Whole House Retrofit	£37,418	£31,431 - £26,193	16-30%	On-site preliminary efficiencies, real-time learning, at-scale delivery, efficient design (by archetype)
Nottinghamshire Net Zero Carbon Housing Demonstrator	£60,875	£50,000	18%	Economies of scale, SCAPE procurement model.
Orbit Housing Incremental Whole House Retrofit Scheme	£55,754	£48,482	15%	Pre-tender piloting (to understand costs), upskilling and facilitating ease of delivery for contractors, regular on-site monitoring for troubleshooting, standardising material and component selection for economies of scale, procurement through existing framework contracts.
Retrofit of Electrically Heated Homes	£49,689	£47,204 - £34,782	5-30%	Delivery at sites within close proximity of each other, strong partnerships within delivery consortium.

Project	Baseline costs (without strategies applied)	Cost reduction target	Estimated cost reduction	Strategy
Social Housing Retrofit Accelerator Cornwall	£105,000	£99,750 - £73,500	5-30%	Process innovation, product innovation.
Warmer Homes Argyll & Bute	£37,000	£35,150 – £25,900	5-30%	Through use of technology (Mauer, Q-Bot), by applying learning from the WHR programme.
Xtra-Z	£56,192	£33,715	40%	Property piloting, surveys, rapid adaptation to the results of real-time monitoring, asset management, economies of scale
WHR				
Destination Zero I	£22,600	£20,000	13%	Through ‘at scale’ model developed by Energiesprong, effective procurement, regular cost reviews, asset management and digital workflow
Energiesprong Sutton	£89,741	£85,254 - £71,793	5-20%	Through ‘at scale’ model developed by Energiesprong, which was expected to: streamline the supply and installation process and thus reduce overheads.

Source: Project reporting

8.2 Evidence of cost reduction

Baseline and endline costs data[85] were subject to significant data quality issues. In addition, six projects had not closed at the time of writing this report, so the data for those projects is not final.[86] Comparisons to baseline and endline per property costs are also limited by the fact that many projects reduced the depth of retrofits from original plans to reduce cost increases, meaning that achieved costs are not directly comparable to those in applications. Additionally, not all measures may have been reported by projects in their reporting as of April 2023. Therefore, the results of the following must be treated with caution as it assumes the data provided by projects is final which is unlikely to be true in all cases.

Nonetheless, when correcting baseline per property costs to only account for the measures actually installed, analysis does indicate that there were some projects where cost reductions may have been achieved:

- Nottinghamshire Net Zero Carbon Housing Demonstrator.
- Social Housing Retrofit Accelerator Cornwall
- Retrofit of Electrically Heated Homes
- Destination Zero II

Analysis also suggests the Alva Community Regeneration through Decarbonisation project was able to stay within 10% of its estimated baseline per property costs for the measures actually installed.

Overall, across all projects, whilst projects on average aimed to reduce costs by 25% compared to the baseline, the data finds that costs increased by 12% on average per property.

In line with this, qualitative evidence from project closure reports strongly indicates that projects struggled to achieve cost reductions as intended. At closure, all six projects who submitted final narrative reports to DESNZ stated that cost reductions were not achieved.[87] Some of these projects reported increased costs as high as 30%, 40% and 47%. In addition, none of the project leads interviewed for this evaluation indicated that their project had achieved any cost reduction.

[85] 'Baseline costs' refer to the costs that projects forecast they would expect the per property and overall cost of retrofit to be in the absence of the cost reduction strategy. 'Endline costs' are the actual final costs of the retrofit.
[86] Clarion Housing Group Advanced Retrofit Project, DORIC, Energiesprong Sutton, National Retrofit Accelerator, Social Housing Retrofit Accelerator Cornwall, Warmer Homes Argyll and Bute.
[87] Only six out of ten completed projects provided final narrative reports, though all provided final quantitative data reports which gave information on the properties retrofitted, their baseline profile and the measures implemented (though there were issues with the quality and comprehensiveness of this data, as set out in detail in the Technical Annex).

8.3 Key barriers to cost reduction

Following the discussion above, this section reports on the main barriers to cost reduction.

8.3.1 Inflationary pressures

Inflationary pressures from the wider macroeconomic situation was a key factor cited by multiple projects in both final reports and project lead interviews as reasons for cost increases. This pushed up prices across the board for both materials and labour costs. The analysis of cost reduction controlled for inflation by using the construction price index in constructing costs, as set out in the Technical Annex

> *"[With the] cost of materials rising and cost of living crisis, [there] cannot be a cost reduction." – Project lead (interview)*

This general sentiment was reflected by numerous others in both interviews and final reports.

These pressures ultimately led to cost reduction being a lesser focus for some projects with one project reporting:

> *"With COVID-19, procurement delays, supply chain issues, we didn't end up with cost reduction as the main driver." – Project lead (interview)*

> *"Cost saving was achieved by reducing the number of houses completed [i.e. scale]. It just was not affordable to complete all retrofits, because of the rise in material and contractor charges during the project." – Project lead (interview)*

Due to the unpredictable nature of inflation, it is difficult to fully factor in its impact into project budgets at the outset. However, projects can devise contingency plans and take steps to mitigate the potential uncertainty and negative effects of inflation. Section 8.4 details some of the strategies projects undertook to control costs.

8.3.2 Limited supply chain capacity

Concurrent implementation of the two programmes led to an increase in demand for a limited pool of labour, suppliers and installers. This eventually led to shortages, increased costs and delays. This is covered in greater detail in the process evaluation.[88]

This challenge was more acute for the projects participating in SHDF(D), due to the added requirement to use PAS 2035/2030 compliant installers. A few SHDF(D) projects mentioned a lack of PAS accredited installers as a key constraint to project delivery, both in their documentation as well as interviews.

[88] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

8.3.3 Remedial works and (other) unanticipated costs

While projects were aware that remedial works would be likely in the properties, many projects encountered unplanned or higher remedial costs than expected, resulting in higher overall costs. Lack of sufficient ex-ante data and knowledge on the condition of the housing stock selected for retrofit might have contributed to this. The diverse nature of the UK housing stock, which often lacks comprehensive records, especially for older properties, combined with the inherent variability in construction practices and undocumented modifications over the years, can lead to unforeseen challenges during retrofit.

The QCA confirmed that the presence or absence of unanticipated remedial works plays a pivotal role in whether projects stay within their initial estimates of cost per retrofit. QCA was used to analyse the conditions (or combinations of conditions) under which projects achieved their initial unit cost estimates. The conditions analysed were as follows: (i) approach to procurement (ii) whether project took measures to control and manage costs; (iii) whether project ran an initial pilot phase prior to full scale roll-out: and (iv) whether project experienced any unanticipated remedial or enabling works.

Projects that did not have any significant unexpected remedial or enabling works were more likely to meet their initially expected cost per retrofit estimates (within +/-5% range of deviation). However, some projects, like the Orbit Housing Incremental Whole House Retrofit Scheme and Leeds Whole House Retrofit projects managed to achieve their initial unit cost estimates even without this ideal condition. This means that while not having unexpected remedial or enabling works helps, it is not the only way for a project to stay on track with its costs.

Detailed case knowledge acquired as part of the QCA process sheds some light on the nature of unanticipated remedial or enabling works encountered by projects, as summarised in the following box.

Examples of unanticipated remedial or enabling works conducted by projects

Under the WHR Destination Zero I, the actual cost of remedial/enabling works were between £1,600 and £3,000 per property, depending on archetype, as compared to estimated cost of £500 per property. The main driver of remedial works was the extent of works required above windows where it was found that lintels were not installed, or that existing ones were defective. Similarly, under the SHDF(D) Destination Zero II, remedial works increased against expectations where lintels were not installed above, or where existing ones were defective. Given that Destination Zero I and II were delivered practically in parallel the opportunity for learning from the first project to inform cost planning on the second project was limited.

Under the Gloucestershire SHARe and CaRe Demonstrator, an additional £15,548 (averaged across all units) was incurred per project against the original specification for various remedial and enabling works including asbestos sampling and removal, the

resetting of bricks, and work on windows. The Energiesprong Sutton and Xtra-Z SHDF(D) project also experienced unanticipated remedial costs stemming from needing to address asbestos.

Under project DORIC, some homes originally identified through surveys to be suitable for cavity wall insulation proved not to be; consequently, more costly and complex EWI designs (which were not initially anticipated) were required.

Under the Clarion Housing Group Advanced Retrofit project trenching and cable repositioning enabling works were not anticipated prior to the project but were subsequently required.

The Retrofit of Electrically Heated Homes saw enabling costs significantly increase due to the enabling works needed to allow for retrofit without damaging overhead power cables.

Source: project documentation

8.3.4 Insufficient scale

Both the WHR and SHDF(D) programmes were based on the assumption that delivering retrofit to scale is a condition to cost efficiency. Some project team members, when discussing project costs, gave views in which they echoed a similar logic.

> *"If we [ran the project] on a bigger scale - do 20 houses at the same time etc. - then we would get cost reduction based on economy of scale [because] we would reduce travel costs and delivery costs." – Project lead (interview)*

> *"You need to put more units in and get longer term funding to give you that consistency." – Project lead (interview)*

However, retrofits were not delivered at the scale anticipated, so it is not possible using the evidence available, to determine whether delivering at scale leads to cost reductions. However, it has been observed that cost escalations have hampered the ability of projects to achieve scale, especially when project budgets remained fixed.

QCA was used to analyse the conditions (or combinations of conditions) under which projects achieved planned scale[89] (i.e. the number of properties retrofitted by a project as compared to original plans). The conditions analysed were as follows: (i) whether there was disruption (to delivery) from staff or contractor turnover; (ii) little (+/- 5%) or no deviation from initial unit cost estimates; (iii) the number of sites per project; and (iv) whether the project had existing relationships with contractors and suppliers.

[89] One of the objectives of the two programmes was to demonstrate how innovation and scale drive down the cost of retrofit. Projects were thus required to include an appropriate number of properties in their bids to deliver and demonstrate the required economies of scale.

The QCA showed that the projects which achieved planned scale, were those that were able to control and manage their costs to ensure that there was little or no deviation from initial unit cost estimates (Orbit Housing Incremental Whole House Retrofit Scheme, Warmer Homes Argyll & Bute, Nottinghamshire Net Zero Carbon Housing Demonstrator, Alva Community Regeneration through Decarbonisation, Northampton Whole House Retrofit and Leeds Whole House Retrofit). This finding is not surprising: with fixed budgets, any increase in unit costs would naturally lead to a reduction in the number of properties that can be retrofitted. Thus, projects that exceeded their initial costs estimates ended up retrofitting fewer properties than initially planned.

8.4 Cost control measures

Evidence from project reporting and qualitative data collection undertaken for the evaluation and reviewed as part of the QCA, show that projects adopted several strategies to control and manage cost escalation. A typology of these measures is presented below:

- **Reducing the scope of measures installed** (the number or type of measures) - e.g. removal or reduction in the number of air source heat pump installations (as with Orbit Housing Incremental Whole House Retrofit Scheme, Retrofit of Electrically Heated Homes, Northampton Whole House Retrofit and Leeds Whole House Retrofit projects), under floor insulation (as with Gloucestershire SHARe and CaRe Demonstrator projects), or Light Emitting Diodes (LED) lighting (as with Northampton Whole House Retrofit and Leeds Whole House Retrofit projects).
- **Value engineering**[90] **exercises on proposed measures -** Orbit Housing Incremental Whole House Retrofit Scheme used temperature factor calculations at design stage to identify and remove unnecessary work while minimising impact on the overall energy efficiency savings. Furthermore, some properties were provided with cavity wall insulation (instead of EWI) as heat demand calculations showed a minimal difference between the two. This not only removed any associated planning application costs, but also reduced onsite and material costs.
- **Use of cheaper materials / switching to slightly different products** – Brick Slips versus Brick Effect Render including brick art[91] (as with the Orbit Housing Incremental Whole House Retrofit Scheme), use of phenolic insulation on the outside instead of minimal fibre (as with the Nottinghamshire Net Zero Carbon Housing Demonstrator), or using alternative insulation material. The Northampton Whole House Retrofit project

[90] Value engineering (VE) is a systematic and organised approach to providing the necessary functions in a project at the lowest cost. It involves analysing the functions of an item or process to ensure that it's optimized for both performance and costs. In the domain of retrofitting, it is a process where building materials, systems or design strategies are substituted to reduce capital costs while maintaining the desired energy-saving targets, functionality, quality, and reliability.

[91] Brick slips are specially manufactured tiles which when installed have the appearance, colour and texture of a real clay brick, while brick effect render is a textured finish applied to surfaces to mimic the appearance of bricks

reported having used Expanded Polystyrene (EPS) instead of Rock Wool for phase two with a slimmer insultation achieving the same U-value.

- **Adopting flexibility in design** - designing out elements which had knock on effects or materials which had high or volatile pricing and availability. For example, Northampton Whole House Retrofit reported that under phase 2, EWI was not installed below ground (as it went below the damp proof course (DPC)), saving an average £1,894 per retrofit.
- **Process innovation** - one of the innovations cited by Nottinghamshire was that they took the ceiling line rather than the roof line, allowing the loft space to get cold (this avoided having to extend the roof and gable ends).
- **Process simplification** - such as focussing on lower kWh/m/yr target, on fewer archetypes and a limited number of sites.
- **Adapting procurement approaches** - advance / large scale ordering of scarce materials and renting additional storage space to allow for bulk storage of materials so that orders can be placed well in advance and at larger quantities to ensure steady supply over extended periods.
- **Reducing scope of Switchee monitoring**[92] **to a reduced sample of archetype properties** - the Leeds Whole House Retrofit project reported making savings by reducing the number of homes connected to the Switchee monitors.
- **Deselecting properties requiring excessive remedial works** - project DORIC had to deselect properties due to cost of remedial works. Two properties were removed due to their structural frames requiring repair and eight were removed due to their position in a mid or end terrace where the whole terrace would have required retrofit. Initially these properties had been selected due to a poor EPC score.

Although it would have been interesting and insightful to do so, available data did not allow an analysis of the extent to which each of the above measures contributed to cost reduction.

8.5 Exploring contribution

The evaluation highlights the inherent tension between the goal of achieving cost reductions through scale and the practical challenges that hindered this objective.

While a primary aim of WHR and SHDF(D) programmes was to demonstrate how increased scale could lead to cost reductions, only a handful of projects managed to achieve these anticipated costs reductions within WHR and SHDF(D) project delivery. A multitude of factors contributed to this outcome. Foremost among them was the inflationary environment during the project delivery phase. The costs of construction materials soared due to a combination of supply shortages—aggravated by pandemic induced logistical disruptions—and a spike in

[92] https://www.switchee.com

global demand.[93] These inflationary pressures were compounded by other factors previously discussed.

Further complicating matters was the scarcity of specialist suppliers and installers. This was especially pronounced for SHDF(D) projects, which also had to navigate the complexities of PAS2035/2030 compliance.

Some projects indicated that a larger scale of retrofits than was achieved through these innovation programmes is required to benefit from economies of scale and thus, large cost reductions; however, other projects question the feasibility of delivering larger scale with an already stretched and strained supply chain.

To mitigate cost increases, projects developed a number of strategies to keep costs down. Value engineering was carried out to determine the most effective set of measures for the cost. The depth of the retrofit was reduced by reducing the number of measures, or in some cases reducing the number of properties being retrofitted. Cheaper materials were used to bring down costs either by changing materials (e.g. brick slips vs brick effect render), or more expensive material aspects were removed (e.g. aluminium oversills for the windows).

The lack of observed cost reductions does not necessarily invalidate the hypothesis that ‘at scale retrofit and innovation in applying whole house retrofit can lead to a reduced cost per property of the whole house retrofit method, when applied to social housing.’ Among the projects that achieved planned scale (in terms of the number of properties retrofitted) and initial cost per retrofit projects (and hence, target cost reductions) it is not possible to determine the extent to which these cost reductions were driven by scale and/or innovation due to lack of itemised data on final measures (and associated costs) for all projects.

As discussed, two of the principle factors behind cost increases (wider inflationary pressures on material costs as well as constrained market supply) are issues affecting the wider retrofit industry. However project strategies to control costs, within this context, provide useful learnings for future domestic retrofit programmes.

[93] RICS (2021) Construction materials cost increases reach 40-year high, 19 November 2021.

9. Learning Outcomes

This chapter presents the evaluation's conclusions as to whether the programmes were successful at demonstrating the effectiveness of whole house retrofit at scale, and at generating learning for government policymaking and landlord capability for delivering future retrofit.

Chapter 9 at a glance

Both the WHR and the SHDF(D) programmes demonstrated that whole house retrofit at scale remains expensive and difficult to deliver within short timescales.

Overall, the findings of the evaluation do not conclusively support one of the overarching hypothesis of the programmes: that the cost of whole house retrofit could be reduced compared to business as usual through at scale delivery (economies of scale) and through innovation. It is important to caveat these findings, however as the programmes operated in a highly challenging inflationary context. Furthermore, short-term constraints on supply chains also led to delays in delivery and cost escalation. Additionally, the evaluation's brief timeframe and lack of access to final, detailed cost data further complicate a comprehensive assessment. Project team members interviewed still consider that scale can positively affect cost management – i.e. that delivery at scale can reduce costs, where this scale is not impeded by contextual barriers.

The programmes have generated important learning for DESNZ, as well as for Social Housing Landlords. They report that such findings have fed directly into ongoing and future retrofit planning and policy making respectively and, for DESNZ, have informed numerous policy developments, including: the update of the PAS2035/2030 standard and SAP, supply chain resilience policy in central government, and adaptation of programme management processes for delivering the SHDF Main Fund.

It addresses the following evaluation questions:

- To what extent do the programmes demonstrate the effectiveness of WHR at scale?
- Which delivery models have been most successful?
- How much have the schemes helped DESNZ develop their policy portfolio for retrofit?
- How much have the schemes helped expand government capability to support social housing decarbonisation?
- How much have the schemes helped develop landlord capability for delivering future retrofit?

This chapter draws upon evidence from interviews with DESNZ and project teams. It builds upon the assessment of learning processes within both programmes (and their effectiveness) as set out in the process evaluation,[94] as well as on evidence from the QCA.

9.1 The type of learning intended

As set out in the ToCs (see Figures 1 and 2 in chapter 3), both programmes aimed to generate learning for future programming and the potential future application of whole house retrofit. In the case of WHR, this was specifically focused on understanding how to deliver whole house retrofit at scale and at a reduced cost. For SHDF(D), learning had this focus, but the programme was also intended to generate specific understanding of how to roll out the future phases of the programme ('SHDF Main Fund') and the necessary capabilities for doing this. SHDF(D) differed from WHR in that it provided one of the first opportunities for Government to test how PAS2035/2030 could work in practice on a relatively large scale.

The programmes intended to achieve the following learning outcomes:

- Increased capability and greater motivation of landlords, and of the supply chain, to participate in deep retrofit and in future Government net zero building programmes.
- Greater confidence of Government to support future programmes / future waves of the SHDF.
- Learning and know-how being applied in future programmes / future waves of the SHDF with the aim of making the future programmes more effective and efficient.
- The lowering of the costs of delivering newly designed projects as compared to the WHR and SHDF(D) projects (i.e. learnings on cost reduction being fed into future projects).

9.2 Demonstration of the effectiveness of retrofit at scale

Both the WHR and the SHDF(D) programmes demonstrated that whole house retrofit at scale remains expensive, difficult to deliver within short timescales, and highly challenging to deliver as originally planned. Overall, the findings of the evaluation do not support one of the overarching hypothesis of the programmes: that the cost of whole house retrofit could be reduced compared to business as usual through at scale delivery (economies of scale) and through innovation. This is because the evaluation has not found evidence of at scale delivery facilitating cost reduction (absence of evidence), rather than there being evidence of proving that cost reduction does not happen even where there is scale. In summary, the evidence base

[94] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

has been insufficient on which to draw strong conclusions around the relationship between at scale delivery and cost reduction due to impeding contextual factors.

Most projects (10 out of 16) had to reduce the number of properties targeted (i.e. downscale) in order to stay within their (fixed) budget allocations. This was in the face of sharp increases in the costs of labour and materials (due to limited supply chain capacity (see section 7.5 for discussion)), supply chain disruptions (as discussed in detail in the process evaluation),[95] the concurrent implementation of the two programmes creating imbalance between demand and supply (see the process evaluation) and general inflationary pressures (as noted in chapter 2 of this report). Amongst projects that reached their planned scale, the extent to which scale (and/or innovation) contributed to cost reductions cannot be established due to limited project reporting data (as discussed in section 8.2 and – in more detail – in the Technical Annex).

In terms of effective delivery, the evaluation has found the following:

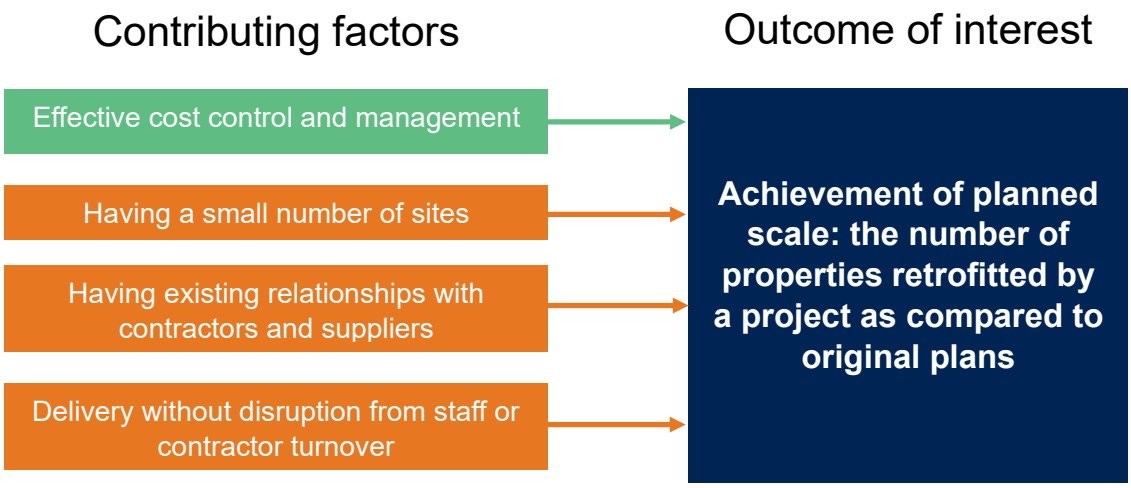
- None of the funded projects across either programme were able to deliver within the timescales originally set.
- Five out of 16 projects were able to deliver retrofit to the original number of properties targeted, with two other projects almost reaching the target (retrofitting one property less and four fewer properties than planned).
- All projects had to make at least some changes in scope or specification of measures from their original plan.
- Four out of 16 projects were able to successfully control and manage costs to stay within their initial unit cost (cost per retrofit) estimates; while two other projects managed to keep cost escalation within acceptable limits (+5%).[96]

Table 12 in chapter 10 sets out differences between planned costs, as an average of total cost by properties retrofitted, and changes in the number of properties retrofitted from planned to achieved.

The evaluation team undertook an in-depth analysis of project documentation and findings from interviews with project teams to assess the factors which most influenced whether a project could be delivered to its original planned scale or not.

[95] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.
[96] This uses the QCA methodology, rather than the cost reduction analysis methodology used in chapter 8.

Figure 18: Diagram of contributing factors and the outcome of interest



The qualitative evidence indicated several factors influencing delivery to scale at the individual project level. Using QCA, the evaluation team reviewed these factors across the 16 remaining projects of the programmes and found that effective cost control and management i.e. little (up to 5%) or no deviation from initial estimates of cost per retrofit was necessary and sufficient for the achievement of scale. Five SHDF(D) projects: Nottinghamshire Net Zero Carbon Housing Demonstrator; Orbit Housing Incremental Whole House Retrofit Scheme in Stratford-upon-Avon; the Alva Community Regeneration through Decarbonisation project in Clackmannanshire; Warmer Homes Argyll & Bute; and the Leeds Whole House Retrofit project were delivered to their originally planned scale of properties. The Northampton Whole House Retrofit project retrofitted 149 out of a target of 150 properties, and Gloucestershire SHARe and CaRe Demonstrator retrofitted 46 (rather than its target of 50). Measure data from the cost reduction analysis suggested that most projects reduced the depth of the retrofits in order to limit cost increases and to remain at scale; however, the data are not of sufficient quality to be able to compare with the results found in the QCA analysis presented here.

From the descriptive analysis of project reporting and interviews with project leads, the following actors were reported to support the achievement of scale (but, following the QCA, did not emerge as sufficient for effective delivery (i.e. in some cases, projects experienced the condition, but then still failed to deliver to scale) nor necessary (i.e. in some cases, projects delivered to scale without the pre-condition).

- Delivery without disruption from staff or contractor turnover.
- Having a small (1-3) number of sites at which retrofit was being delivered.
- Having existing relationships with contractors or partners delivering the retrofits which created trust and efficiency of delivery.

The above factors played a smaller or bigger role in the case of specific projects, but – across the portfolio – when assessed through QCA – did not emerge as universally essential for achievement of scale across the project portfolio.

9.3 Social housing landlord learning on retrofit delivery

As described in detail in the WHR and SHDF(D) process evaluation,[97] both WHR and SHDF(D) established systems and processes in place to facilitate learning and support the implementation of retrofits. DESNZ hosted monthly virtual conferences ('Learning Communities') where participating social housing landlords presented project-related challenges and shared best practice. Project leads spoke positively about this initiative, with lessons shared by other project teams at the Learning Communities influencing their operations. DESNZ also extensively collated lessons shared through these meetings, through project and monitoring and through site visits. The programme Delivery Partner, Ricardo, also played a key role in generating programme learning and in sharing knowledge through its monitoring. Chapter 7 also presents credible evidence of participation in the programmes increasing landlords' understanding of and capabilities in deep retrofit.

A total of 18 local authorities and housing associations that had led projects in WHR and SHDF(D) went on to be successful in their applications to participate in Wave 1 and Wave 2.1 of the SHDF Main Fund;[98] amongst these successful applicants, five local authorities which had participated in SHDF(D) and WHR (Greater Manchester Combined Authority, Leeds City Council, Nottingham City Council Stroud District Council and West Northamptonshire Council) were successful for both waves. Whether learning from WHR and SHDF(D) informed these successful applications and onward delivery of the main fund projects will be assessed as part of the SHDF main fund evaluation.

Experts in whole house retrofit interviewed for this evaluation commented that WHR and SHDF(D) represented positive steps setting the market direction for whole house retrofit, but the shift within the SHDF Main Fund away from whole house retrofit, was perceived to be a lost opportunity for social housing landlords wanting to apply their learning. Similar findings also emerged from some of the interviews with project teams and project leads, as discussed in section 7.3.3 of chapter 7.

> *"It would be nice to see broader availability of funding for whole house retrofit so that we can do some of those maybe Victorian listed properties, or in the conservation areas, which are harder." – Retrofit expert (interview)*

Some whole house retrofit experts also stated that legislative drivers are needed, to increase the roll out and uptake of required measures. Though some uncertainties remain around how legislation would be enforced, or how it would overcome other challenges such as the price of heat pumps being considerably greater than gas central heating systems (see section 8.4 on

[97] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.
[98] See: https://www.gov.uk/government/publications/social-housing-decarbonisation-fund-wave-1-successful-bids/social-housing-decarbonisation-fund-wave-1-successful-bids and https://www.gov.uk/government/publications/social-housing-decarbonisation-fund-wave-21-successful-bids/social-housing-decarbonisation-fund-wave-21-successful-bids

cost control measures and chapter 10 for a discussion of current value for money in delivering the whole house retrofit programmes).

> *"We now know the standard to which the government wants us to deliver whole house retrofit. But we don't know how many homes it should be delivered to. We also don't know how to do it step by step in a safe way…we don't know what level to do it to, in terms of level of insulation or level of carbon emissions reduction… Definitely we need a really clear picture of where it fits in the government thinking and also the reasons why they want to see retrofit. If it's just climate, fine or is it fuel poverty or is it health or is it all of those things." – Retrofit expert (interview)*

9.4 DESNZ learnings for retrofit policymaking

As reported in the WHR and SHDF(D) process evaluation, DESNZ delivery team members reported in interviews that learnings from the SHDF(D) fed directly into future policy making and informed numerous policy developments, including: the update of the PAS2035/2030 standard and Standard Assessment Procedure (SAP), supply chain resilience policy in central government, and adaptation of programme management processes for delivering the SHDF Main Fund.

As part of this outcome evaluation, a further 12 interviews were conducted with DESNZ officials involved in programme delivery. All interviewees confirmed that the programmes had generated learning and knowledge which they had applied into ongoing programming and policymaking. SHDF(D) officials stated that learnings had explicitly fed into SHDF Main Fund.

Key areas of learning that were applied to SHDF Main Fund and other DESNZ programmes comprised:

- How to best balance the achievement of environmental benefits with other target benefits including value for money, cost reduction and resident satisfaction, as routes to achieving these benefits can sometimes be conflicting (e.g. the most economic retrofits are likely to involve fewer measures and may therefore have smaller environmental benefits).
- How to distribute grant funding in such a way as to optimise timely and effective delivery by social housing landlords.
- How to work with housing associations directly in delivering retrofit at scale.
- How retrofit costs are generated and how, if at all, they can be managed.
- The effects of short timelines on delivery – interviewees commented that Demonstrator 'proved' that 12 months for installations was too short and this was changed in subsequent waves.
- The need for a more thorough assessment of the potential risks and impacts of programme requirements before starting a programme. In the case of SHDF(D),

PAS2035/2030 placed significant obligations on projects, and the implications of these had not been fully considered before starting the programme.

The DESNZ officials interviewed reported that they had shared learning from the programmes with the Department for Levelling Up Housing and Communities (DLUHC) in relation to social housing improvements and local regeneration, as well as with the Departments for Education (DfE) and for Work and Pensions (DWP) in relation to the skills needed and potential and career paths into the retrofit sector. Additionally, it was mentioned that the Energy Efficiency Task Force recently announced a subgroup on social housing which is drawing on learning from WHR and SHDF(D).

However, DESNZ officials also recognised that the programmes had not been able to answer key policy questions on: (1) the optimal amount of time for projects to complete retrofits (which should be factored into future programmes); and (2) how to increase skills in retrofit to the levels sufficient to optimise delivery capacity in the sector, and with which departments and/or bodies such skills development should lie.

Had the programmes been delivered within the policy and economic context anticipated (where projects had not been as severely affected by inflation and supply chain challenges), it may have been possible for the programmes to generate greater certainty around optimal and average timescales for retrofit, as well as costs (see section 9.2 for further discussion).

On skills, the discussion in chapter 7 suggests that WHR and SHDF(D) were effective in increasing skills within the companies supported, and also suggests that participating companies saw pathways to applying these skills to future and ongoing work. The second policy question will be further assessed in the SHDF Wave 1 and Wave 2.1 evaluations as an assessment of whether and how companies participating in WHR and SHDF(D) have contributed to onward delivery capacity in the sector.

DESNZ officials reported in interviews that there was a lack of information provided to them at the start of the SHDF(D) programme, meaning that they did not have all the necessary details and knowledge to set up the programme effectively. For example, they stated that, if the teams were aware the projects would have to be extended, they would have dedicated a greater amount of time to consolidate certain processes, documents, and approaches to reporting and organising shared tools in a more efficient and accessible way.

It has not been possible within the timeframes of this evaluation to comprehensively assess the extent to which subsequent social housing retrofit delivery has embedded learnings from the SHDF(D) and WHR programmes. An assessment of how SHDF(D)/WHR learnings have supported (or hindered) future policymaking in the SHDF will be assessed through evaluations of the SHDF Main Fund.

10. Value for Money

This chapter presents the economic evaluation (also referred to as a value for money (VfM) assessment for WHR and SHDF(D).

Section 10 at a glance

The total level of expenditure for the SHDF(D) programme, including grant and matched funding, is £84 million, £9 million less than the initial planned expenditure, and for the WHR programme expenditure has been £11 million below budget at £7 million.

Funded projects have not delivered the number of retrofit measures that were expected at the outset of the programmes (around 55% of measures were installed). This was largely due to cost increases in materials, equipment and labour over the delivery period and to unforeseen challenges in retrofitting within individual projects. 12 of the 16 projects had a cost per retrofitted property higher than anticipated.

Overall outcomes were achieved for both residents and participating companies and social housing landlords, though not as extensively or consistently as anticipated.

The aim of the economic evaluation of the SHDF(D) / WHR programme was to contribute towards the overall evaluation aims of:

- Providing an in-depth analysis of the costs of the programmes and weighing these against the outcomes delivered; and
- Generating lessons from findings, as they emerge, to inform DESNZ, local authorities, housing associations (i.e. social housing landlords), whole house retrofit providers and other key stakeholders as to the different values of approaches taken and to support the design of future schemes and projects.

The analysis uses the National Audit Office's (NAO) 4E's framework,[99] and assesses the programmes in terms of economy, efficiency, effectiveness and equity.[100] This VfM assessment draws on findings from semi-structured interviews with DESNZ officials, project leads and project team members, qualitative research and a survey of residents, programme level management information, and data from secondary sources. The findings draw heavily on the programme description and outcome evaluation presented in the preceding sections (sections 4 to 9). Further details on the rationale for using the 4E's framework and data sources used can be found in the Technical Annex.

[99] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/49551/DFID-approach-value-money.pdf

[100] Equity refers to the extent to which services are available to and reach all people that they are intended to – spending fairly. See: https://www.nao.org.uk/successful-commissioning/general-principles/value-for-money/assessing-value-for-money/ for information.

The research team explored in detail the feasibility of undertaking different approaches to a Value for Money assessment, including a Cost Benefit Analysis and Cost Effectiveness Analysis. However, due to the types of outcomes achieved by the programmes, and a lack of available data, these approaches were not utilised.

There were some limitations to the ability of this evaluation to assess VfM. These are set out in detail in the Technical Annex, but can be summarised as:

- **Inability to disentangle programme-level outcomes**: Many of the outcomes of the programmes were linked together and were challenging to disentangle from one another and it was not possible to apportion input costs to specific outcomes. This meant that the evaluation was only able to provide estimates of the cost per retrofit completed.
- **Inability to disaggregate outputs and outcomes by project**: Due to the data collected and the national coverage of the project teams delivering retrofit activities for the programmes, it has not been possible to disaggregate outputs (beyond properties receiving retrofit measures) and tenant and economic outcomes by project.
- **Limited direct comparability with other schemes**: The qualitative nature of the approach taken meant that it was not possible to robustly benchmark findings to the findings of economic evaluations of comparable schemes.
- **Data availability**: Some data which would have been useful to support the economic evaluation was not available. For example, most projects had not reported a cost per measure installed per property. Therefore, it has been challenging to develop benchmarks to assess the economy of the projects at the measure-level.
- **Timing of the evaluation**: The time period over which some of the outcomes were expected to be observable (for example the economic, wellbeing and environmental outcomes) did not fall within the evaluation timeframes. Therefore, a full assessment of the outcomes of the programmes could not be achieved.
- **Analysis undertaken at both project and programme level**: The economic evaluation had to undertake some analysis at a project level (incorporating only project costs) and some at programme level, on the basis of available data. Where analysis has been conducted at a programme level, the whole programme costs have been used.

10.1 Expenditure

The expenditure required to deliver the SHDF(D) and WHR programmes is presented in Table 10 and Table 11 below. This shows that a total of £38 million of DESNZ funding has been spent on the SHDF(D) programme to July 2023, which has been grant funding to local authorities to deliver projects. For WHR, a total of £3 million of DESNZ funding has been spent. However, both projects also included significant proportions of match funding from local authorities / the housing associations involved – £45 million for SHDF(D) and £4 million for WHR (55% of the total SHDF(D) budget and 60% of the WHR budget). This expenditure has

been used to deliver the portfolio of 14 SHDF(D) and two WHR projects. In addition to the funding, staff time for DESNZ staff and administration costs have also been incurred to deliver the programmes, but these are not included in the total cost of the programmes.

These figures compare to an initial DESNZ grant funding and match funding budget of £93 million for the SHDF(D) programme and £19 million for the WHR programme. There has been an underspend against the initial budgets (including DESNZ and match funding), set out in the project applications, of £21 million (19%), with most of the decrease in expenditure being in the WHR programme (£11 million, 62%). This underspend was driven principally by a reduction in the cost of four projects - Energiesprong Sutton and Destination Zero I (both WHR projects with a reduction in total cost of greater than 60%), the National Net Zero Retrofit Accelerator (a reduction in costs of nearly 20%) and Destination Zero II: The Next Step (a reduction in costs of more than 10%). One project (Alva Community Regeneration through Decarbonisation – Weir Multicom Non Traditional House Upgrade – 2020-21) had expenditure slightly above the initial budget (an increase of just under 4%).

Table 10: Expenditure for the SHDF(D) programme

Expenditure item	Expenditure (£'000)
SHDF(D) capital grant expenditure	£38,028
SHDF(D) match funding	£45,764
Total including match funding for SHDF	£83,792

Source: DESNZ internal records, as of August 2023

Table 11: Expenditure for the WHR programme

Expenditure item	Expenditure (£'000)
WHR grant funding	£2,849
WHR match funding	£4,232
Total including match funding for WHR	£7,081

Source: DESNZ internal records, as of August 2023

10.2 Economy

The NAO approach to assessing value for money defines 'economy' as being the minimisation of the costs or resources used to deliver an intervention. In order to assess the economy of the SHDF(D) and WHR programmes, the research team and DESNZ agreed to use the following evaluation questions:

- What was the cost for the activities delivered and how did these compare to expectations?
- How have projects minimised the costs / cost escalations for each activity?

The main activities delivered by the SHDF(D) and WHR projects were the retrofit measures that were installed.

The cost to deliver retrofits is explored in detail in Chapter 8. Evidence collected from project documentation and interviews with project leads and project teams indicates that most projects experienced cost escalations and the costs to deliver retrofit measures were higher than they anticipated in their applications, largely due to wider economic and market drivers. However, there were some factors which contributed to increases in the costs of delivering measures which were more closely related to programme design or delivery, such as the simultaneous delivery – and pressure on the supply chain – of two similar programmes. These are highlighted in section 8.3. Cost increases led to a reduction in the number of measures installed in 14 of the 16 projects. As highlighted in the chapter, several strategies were introduced to attempt to control the costs of the retrofits, including reducing the number of measures installed and value engineering.

10.3 Efficiency

The NAO approach to assessing value for money defines ‘efficiency’ as the relationship between the output from goods or services and the resources to produce them. For the SHDF(D) and WHR programmes, this relates to the outputs of number of homes retrofitted, homes with at least an EPC C energy rating, supply chain staff undertaking training, and innovations trialled. In order to assess the efficiency of the SHDF(D) and WHR programmes, the research team and DESNZ agreed to use the following evaluation questions:

- What were the costs to achieve outputs, how do these compare to expectations and do these offer value for money?
- What factors contributed to the differences in expected cost per property upgraded?

As described in the process evaluation[101] and in section 10.2 above, there were significant challenges which impacted upon the delivery of the portfolio of projects which had an effect on the cost per outputs achieved. In particular, these impacts affected the cost per property upgraded, as building materials and labour were more expensive than anticipated at the outset of the programmes.

[101] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

10.3.1 Project-level efficiency

Table 12 overleaf clearly shows that most projects reduced the number of properties retrofitted, as well as the number of measures installed, from their original plans.

Table 12: Expected and actual expenditure, retrofitted properties and measures installed by project, as of April 2023[102]

Project	Project cost (grant and matched funding)		Number of properties to be retrofitted		Number of measures installed	
	Application stage - £'000	**As of April 2023 - £'000**	**Application stage**	**As of April 2023**	**Application stage**	**As of April 2023**
Nottinghamshire Net Zero Carbon Housing Demonstrator	£1,500	£1,500	25	25	150	87
Orbit Housing Incremental Whole House Retrofit Scheme	£3,623	£3,623	69	69	552	377
Social Housing Retrofit Accelerator Cornwall	£4,026	£4,026	75	40	280	160
Warmer Homes Argyll & Bute	£4,922	£4,922	130	130	910	515
Retrofit of Electrically Heated Homes	£7,709	£7,709	236	176	1408	1021
Gloucestershire SHARe and CaRe Demonstrator	£2,264	£2,264	50	46	322	225
Destination Zero II: The Next Step	£5,467	£4,733	104	65	455	209
Project DORIC (Domestic Optimised Retrofit Innovation Concept)	£5,233	£5,233	100	50	400	286
Alva Community Regeneration through Decarbonisation – Weir Multicom Non Traditional House Upgrade – 2020-21	£775	£805	15	15	75	120

[102] This table draws on project data available at the time of analysis, April 2023 and cannot be considered final as some projects were still ongoing. It does not include 20 communal spaces to be retrofitted. The total scheme-level expenditure is therefore slightly different to those presented in tables 10 and 11, which are updated to the latest figures as of the time of writing (August 2023).

Project	Project cost (grant and matched funding)		Number of properties to be retrofitted		Number of measures installed	
Clarion Housing Group Advanced Retrofit Project	£8,985	£8,985	160	116	928	367
Northampton Whole House Retrofit	£5,613	£5,613	150	149	1043	350
Xtra-Z (cross-tenure retrofit achieving zero carbon)	£7,800	£7,800	164	90	540	463
National Net Zero Retrofit Accelerator	£26,406	£21,745	270	129	903	750
Leeds Whole House Retrofit	£8,870	£8,870	190	193	1351	252
Energiesprong Sutton	£8,574	£3,222	100	23	161	138
Destination Zero I	£10,199	£3,860	180	51	400	118
SHDF(D) total	**£93,194**	**£87,829**	**1,738**	**1,293**	**9,317**	**5,182**
WHR total	**£18,773**	**£7,081**	**280**	**74**	**561**	**256**
Combined total	**£111,967**	**£94,910**	**2,018**	**1,367**	**9,878**	**5,438**

At a portfolio level, the programmes have seen:

- A considerably lower number of properties retrofitted (-33%, with -26% for SHDF(D) and -75% for WHR);
- A significantly lower number of measures installed per property (-41%, for both programmes)

However, though projects reduced the number of measures installed, the analysis presented in Chapter 5 finds that all 74 properties in WHR achieved an EPC rating of C or higher, and 79% of properties in SHDF(D) achieved EPC rating of C or higher (there was insufficient property data to estimate EPC changes for a further 19%). Given the low number of properties which did not achieve an EPC C or above rating, it is unlikely that all of the measures included in the project applications were required to achieve the output of improving the energy efficiency of the property. This means that – in this sense – projects were economic with the number of measures they installed to achieve project targets.

Chapter 7 details other outputs the programmes have achieved, for example increasing the capacity and capability of the supply chain (see section 7.3 for more details). The evaluation has been unable to provide a quantitative assessment of the scale or costs of training, however, as there was no available data on the number of staff who have received training, the type of training received, or the extent to which costs of training are accounted for in the project-level expenditure detailed in Table 12 (as suppliers charge a cost of labour which it is assumed will include some costs of training).

10.3.1 Programme level efficiency

The economic evaluation also explored efficiency at a programme level, aiming to explore what factors at a programme level supported efficient delivery of outputs. One of the key aspects of the programme level efficiency were lessons learned, as the projects were pilots. The key findings for lessons learned are presented in Chapter 9.

A further aspect of the efficiency was the effect of delivering the two programmes together. A small number of Government stakeholders reported their belief that by providing the two programmes together at scale, with the large amount of public and matched funding, the supply chain had an increased incentive to upskill to deliver the retrofits and increased their skills base and efficiency for delivering retrofits in the future. The discussion in chapter 7.3 suggests that for companies participating in SHDF(D) and WHR, staff were able to increase their skills and they expect to apply this going forward in future projects. However, it has not been possible within the timeframe of this evaluation to assess the sustainability of those effects.

10.4 Effectiveness

The NAO approach to assessing value for money defines 'effectiveness' as the relationship between the intended and actual results of public spending (outcomes). The outcomes of the SHDF(D) and WHR programmes are set out in the programme ToCs in chapter 3. In order to assess the effectiveness of the SHDF(D) and WHR programmes, the research team and DESNZ agreed to use the following evaluation questions:

- What outcomes have been achieved by the programme and how does this compare to expected outcomes in the business case/theory of change?
- What factors contributed to the outcomes achieved?
- How reasonable were the costs in relation to the outcomes achieved?

Due to the interaction between the retrofit projects/intended effects and the multiple outcomes they contribute towards, it has not been possible to identify a cost per outcome achieved. Therefore, a more qualitative approach has been taken to assess the effectiveness of the SHDF(D) and WHR programmes.

An assessment of the outcomes achieved by the programmes are presented in the preceding chapters (4 to 9).

The main outcomes that the evaluation could demonstrate had been achieved at the time of the research related to residents, with resident satisfaction with retrofits, estimated reductions in bill payments (through modelled research) and improvements in building quality and appearance all achieved (see chapters 5 and 6 for more details). Further, the modelling analysis suggests that the programmes have also contributed to reductions in carbon emissions.

There is also strong evidence that the programmes have generated significant learning for DESNZ, local authorities, landlords and suppliers. This was a key aim of the programmes as demonstrator pilots/innovation programmes (see chapter 9). There is potentially significant value for future programmes in understanding what approaches, innovations and interventions will not work, so they can be avoided. This presents a challenge for assessing the effectiveness of the programmes as the value of the lessons learned will not be realised until future delivery of retrofit programmes has taken place.

There is less evidence to support the hypotheses that the cost reduction outcomes that were anticipated have been achieved (see Chapter 8 on cost reductions).

There is also mixed evidence to support claims that the programmes have contributed to market outcomes. The evidence suggests that there has been an increase in the number of jobs at companies participating in the programmes, and there has been an increase in the skills base of individuals at these firms to deliver retrofit activities. However, at the time of writing (June 2023), it is not possible to confidently attribute these changes to the programmes.

The timing of the evaluation is an important factor in these findings. However, the evaluation found evidence that was an increase in supply chain confidence and the companies' reputation for delivering retrofit activities as a result of the programmes, which could lead to an increase in jobs and skills base in the future (see chapter 7 for detailed assessment of jobs and skills outcomes).

These outcomes have been achieved at a cost to DESNZ of approximately £40 million for SHDF(D) (£88 million including match funding) and £3 million for WHR (£7 million including match funding).

At the time the evaluation was undertaken, the main benefits of the programmes were being experienced by residents in the properties retrofitted, and there was limited evidence of wider spillover benefits into the economy. However, there were two outcomes that the programmes have achieved which offer wider benefits to society. These are the reduction in carbon emissions, which would benefit the whole economy, and the potential value of the learning achieved providing better value for money for future public expenditure – for example that whole house retrofit at scale remains expensive, and difficult to deliver within short timescales.

10.5 Equity

The NAO frameworks definition of 'equity' is the extent to which services are available to and reach all people that they are intended to. In order to assess the

equity of the SHDF(D) and WHR programmes, the research team and DESNZ agreed to use the following evaluation questions:

- Were the programmes / projects designed and delivered in economically disadvantaged areas?
- Did the projects benefit individuals in need of public intervention?
- Did the processes used by local authorities promote an equitable distribution of funds?

10.5.1 Were the projects delivered in economically disadvantaged areas?

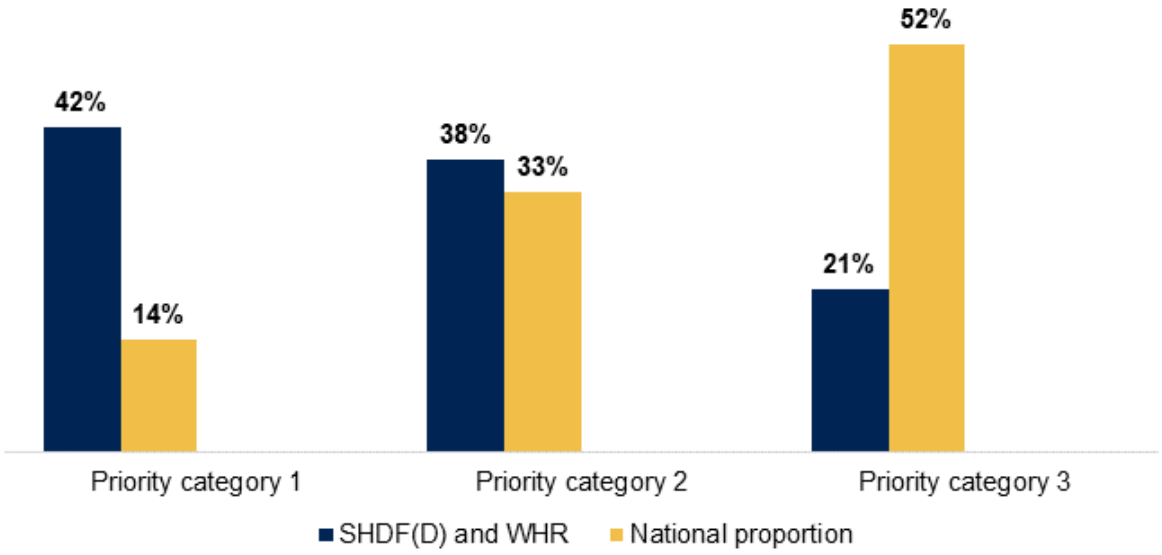
WHR and SHDF(D) retrofit projects were delivered in a wide variety of locations, as would be expected as the projects were not designed to target economically disadvantaged areas. However, in order to assess the equity of the programmes, the evaluation explored the relative economic disadvantage of areas receiving funding, to ensure the public funding was not concentrated in areas with less economic need (and that expenditure was equitable). Therefore, the evaluation assessed the equity of the programmes by exploring the degree of need of investment in the intervention areas, using Levelling Up Priority areas and Index of Multiple Deprivation (IMD) data.

Figure 18 shows the number of SHDF(D) and WHR projects that were delivered in local authorities in each of the Levelling Up Priority categories in the Levelling Up Fund Index.

These categories have been developed using indicators such as local productivity, unemployment, skills, dwelling and commercial vacancy rates and average journey times. Priority category one indicates areas deemed in most need of investment, with areas in Priority category three deemed to be least in need of investment. Across the UK, around half of local authorities are in Priority category three, with just over 10% of local authorities in the Priority category one.

As Figure 19 shows the proportion of local authorities in which the SHDF(D) and WHR projects were delivered in Priority category one was higher than the national average proportion of local authorities in the Priority category. This suggests that although the programmes did not specifically target the levelling up agenda, they could be judged to have contributed towards it.

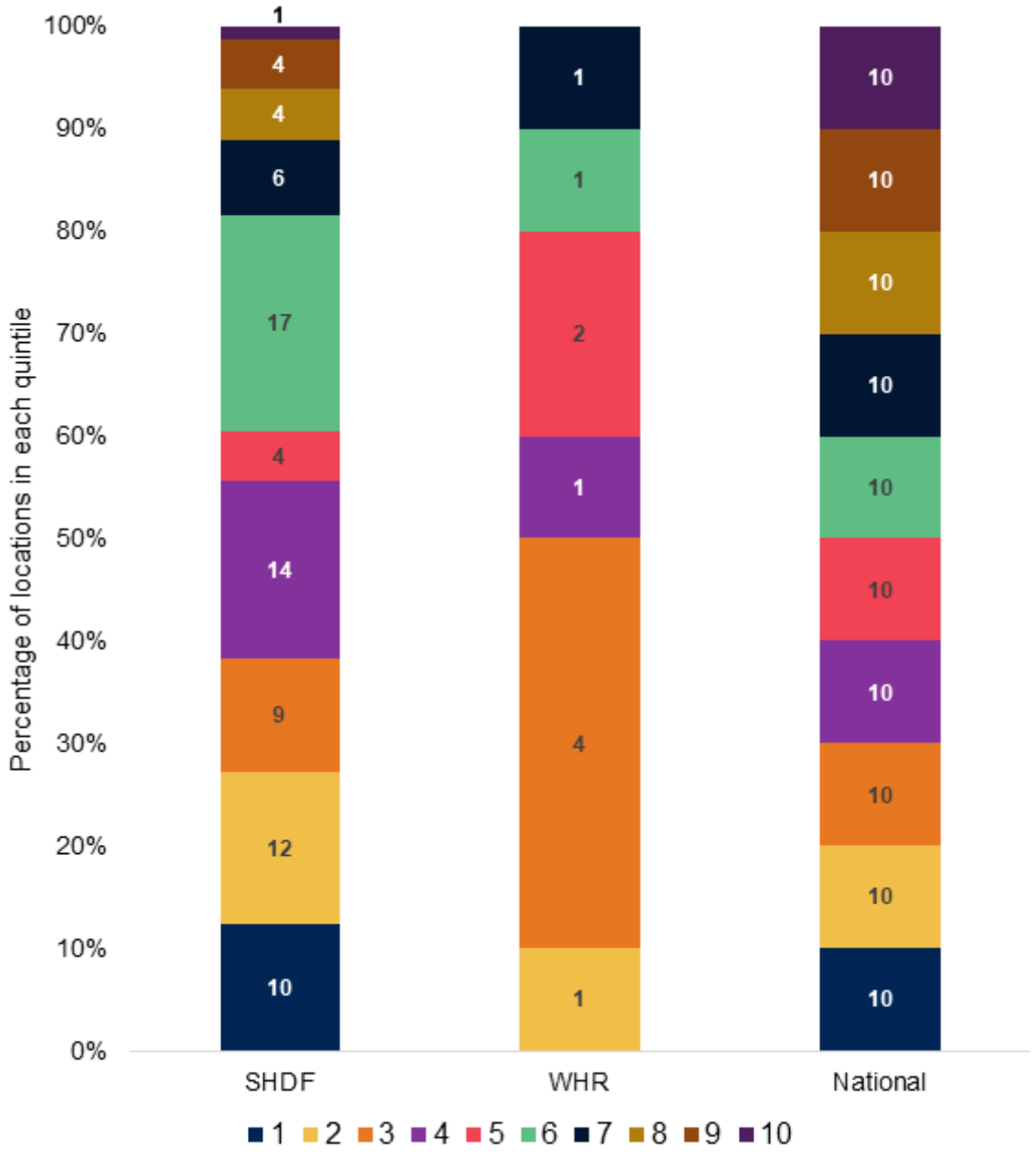
Figure 19: SHDF(D) and WHR local authorities by Levelling Up priority area



Source: Department for Levelling Up, Housing and Communities Levelling Up Index

The SHDF(D) and WHR projects were delivered in specific areas within the selected local authorities. The research team analysed Index of Multiple Deprivation (IMD) data for the lower super output areas that the SHDF(D) and WHR projects were delivered in. The IMD is a measure of relative poverty in areas. Again, there were a wide variety of areas that the projects operated in, with projects operating in areas in each of the IMD decile. However, more than half of the lower super output areas in which the SHDF(D) and WHR were delivered in were in areas in the bottom four IMD deciles (above national average levels of poverty)

Figure 20: SHDF(D) and WHR project locations by IMD decile



Source: ONS Census 2021, data analysed at Lower Super Output area level

The SHDF(D) and WHR projects were not set up to target economically disadvantaged areas or to support the Levelling Up Agenda. However, these findings suggest that the funding has gone to areas with above average levels of poverty (those in the lower IMD quintiles) and those more in need of support (in local authority areas identified as more in need of investment in the Levelling Up Index). This suggests that the distribution of public expenditure has to large degree been equitable from an economic perspective.

10.5.2 Project beneficiaries

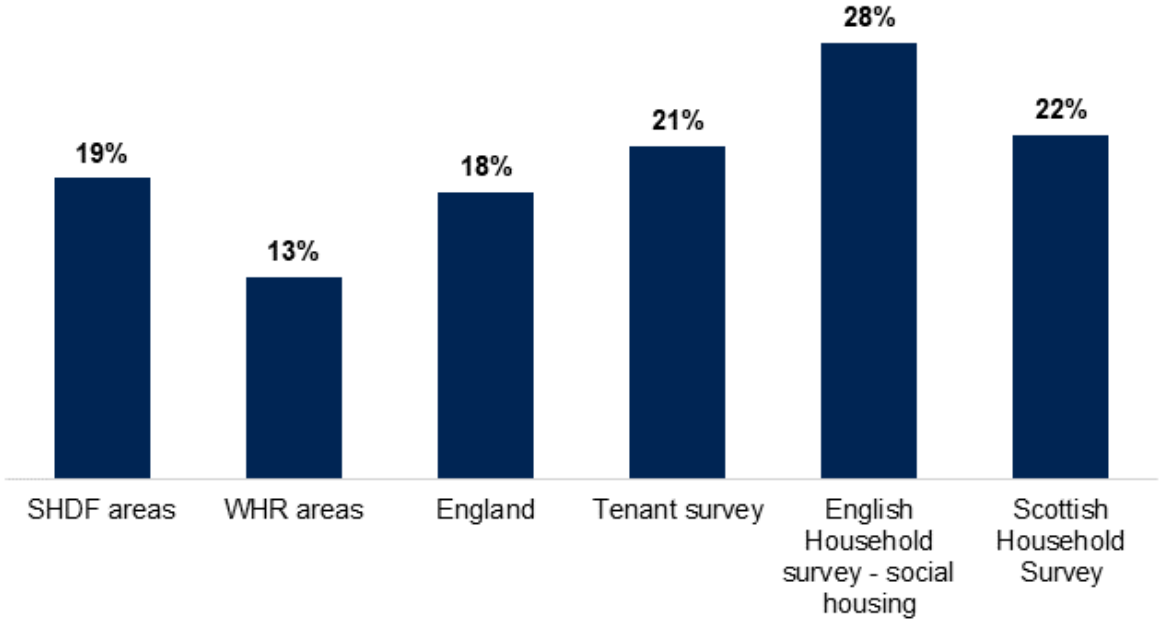
The analysis has also explored whether beneficiary residents with particular characteristics were more or less likely than the national profile of social housing residents to receive retrofit installations. Data from the resident survey and secondary data sources, such as the Census were analysed to explore characteristics of the beneficiaries and the local populations where projects were delivered.

Age

The age profile of the areas in which the SHDF(D) and WHR projects operated in was explored with a particular focus on individuals aged 65 and over, as this age group, particularly those in social housing, are likely to be on a low fixed income[103].

This showed that the areas in which the SHDF(D) projects operated in are broadly in line with national average (but lower than the average for social housing tenants), suggesting age was not a barrier to participation. Around 19% of the national population are aged 65 or over (28% of the social housing population according to the English Household Survey); the responses from the tenant survey indicating around 21% of residents in surveyed households were aged 65 or over. However, the areas in which WHR operated has a lower proportion of the population aged 65 and over, at 13%. This is still within six percentage points of the national average (19%). However it should be noted these are not representative of the total SHDF(D)/WHR population (see Technical Annex for discussion).

Figure 21: Individuals aged 65 and over in SHDF(D) and WHR project areas, nationally and resident survey responses



[103] Age UK (2023) Poverty in Later Life. This report finds that 36% of older people living in socially rented accommodation live in relative poverty.

Source: ONS Census 2021, data analysed at Middle Level Super Output area level; England Household Survey 2022, and Findings from the evaluation resident survey (base=534 household members). Note the resident survey includes responses from Clackmannanshire, in Scotland, whereas the Census and English Household Survey only include data for England. Scottish Household Survey data also included – though this relates to the proportion of highest earners aged over 60.

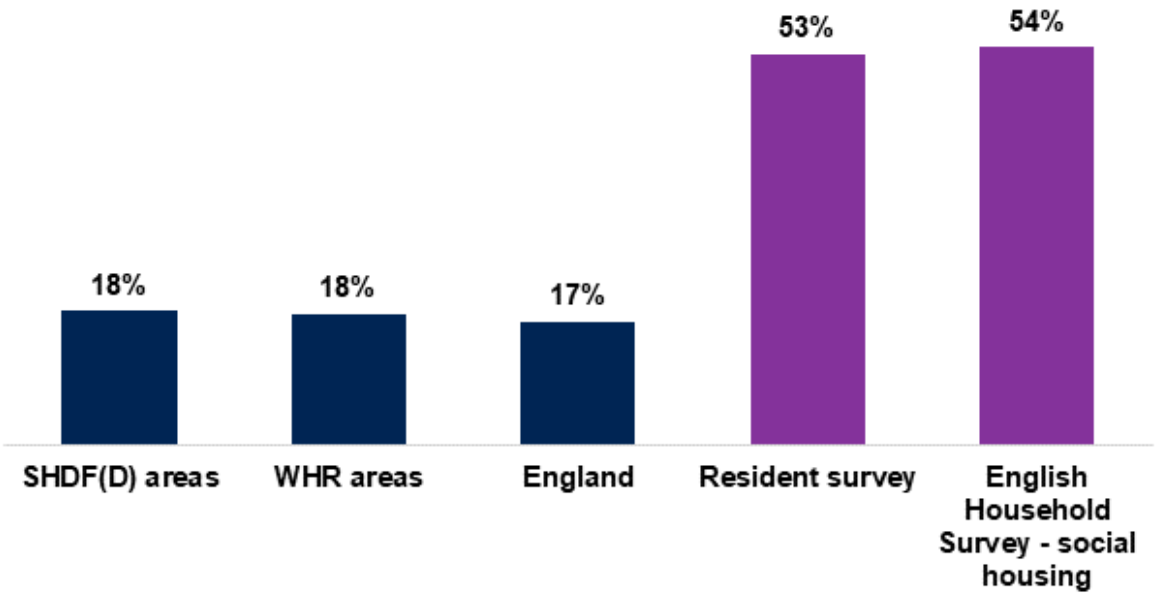
However, the findings from the process evaluation[104] indicated that several projects experienced difficulties convincing residents to participate in the retrofit, and in some cases this was particularly acute for older residents, for reasons such as not believing they would benefit in the longer-term from the interventions installed and the risk of the spread of COVID-19 through participating in the project. This may have prevented older individuals from benefitting from the outcomes of the programme. Despite this, there is no evidence that the design, or implementation of the projects particularly hindered access to the outcomes for individuals of different ages, and Figure 21 above does not provide strong evidence of barriers for those aged 65 or above.

Disability

Census data shows that the areas in which the SHDF(D) and WHR projects were located had similar proportions of individuals who had a disability under the equalities act, and this was in line with the national average (16%). However, individuals in social housing, where all of the interventions were delivered, are more likely to have a disability than those in other forms of housing, as shown in the English Household survey, with just over half of individuals reporting that they had a disability.[105] A similar proportion of respondents in our resident survey stated they had a disability (53%). The analysis of these data sources suggests that people with disabilities have not been disadvantaged by the targeting of the SHDF(D) and WHR projects.

[104] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.
[105] The UK Household Survey uses a different definition of disability to the census, with the question in the survey asking if individuals have a disability which leads to substantial difficulties.

Figure 22: Individuals reporting they have a disability in SHDF(D) and WHR project areas, nationally and resident survey responses

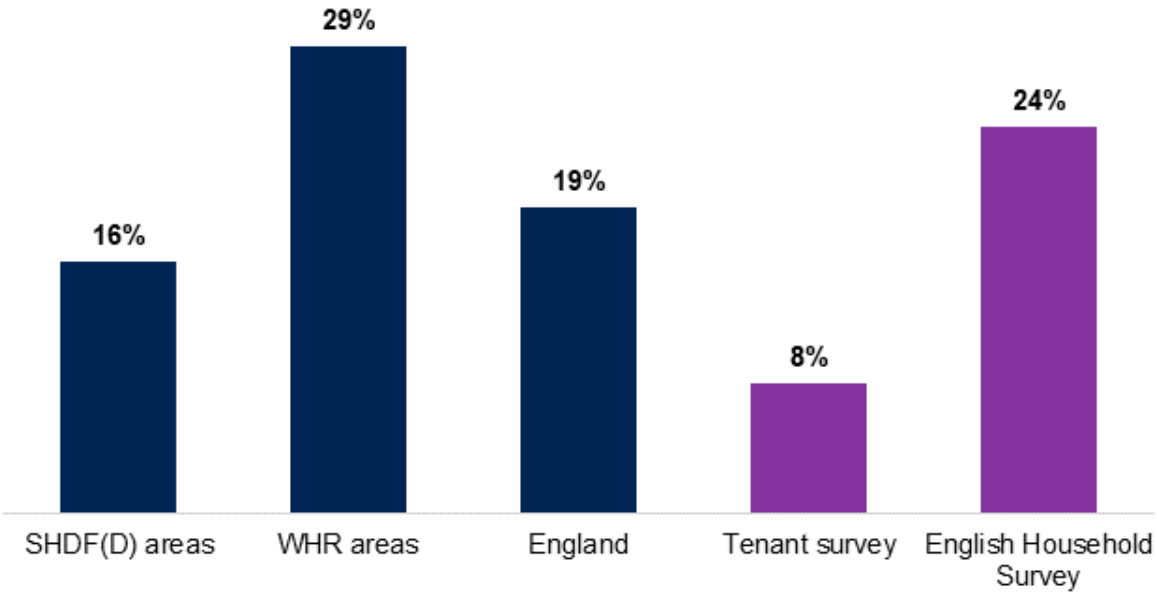


Source: ONS Census 2021, data analysed at Lower Super Output area level; UK Household Survey 2022, and Findings from the evaluation resident survey (base=534)

Ethnicity

Census data shows that the areas in which the SHDF(D) and WHR projects operated in had similar proportions of ethnic minority individuals relative to the national profile, with between 15% to 30% of individuals in the areas of projects being ethnic minorities. This suggests that people from ethnic minority backgrounds have not been disadvantaged by the location of the SHDF(D) and WHR projects. The resident survey however, found a much smaller proportion of individuals identifying from ethnic minority groups – however the resident survey was not representative of the total population, and there was no evidence that ethnic minority individuals were disadvantaged in the qualitative interviews with landlords, residents and the supply chain.

Figure 23: Individuals from ethnic minority backgrounds in SHDF(D) and WHR project areas, nationally and resident survey responses



Source: ONS Census 2021, data analysed at Middle Layer Super Output area level.

10.5.3 Process equity

The selection of properties to take part in the projects varied between projects. However, project lead interviewees across all projects suggested that the main reason properties were selected was based on their retrofit need. Either selecting properties that were hard to treat, and therefore would be unlikely to receive any interventions in the absence of the projects (as the properties would have been more expensive to retrofit), or those that had specific retrofit needs. There is no evidence to suggest that equity considerations were used as part of the property selection process.

Following the selection of properties, projects needed to engage with residents to secure participation in the retrofits. The approaches and their relative effectiveness have been assessed in the process evaluation.[106] However, the process evaluation did not collect any evidence on whether equity was considered as part of the engagement strategy.

The process evaluation also details that the procurement routes used by local authorities and their social housing landlord partners varied between projects. Some local authorities and housing associations used existing framework contracts they held, whereas others conducted new procurement activities, either themselves or subcontracted through an external provider to speed up the process of contracting. The evaluation has not collected evidence as to whether

[106] Joint Process Evaluation Report - Whole House Retrofit (WHR) and Social Housing Decarbonisation Fund Demonstrator (SHDF(D)), BEIS/DESNZ Research Paper Series Number 2023/008.

equity considerations were used in any of the procurement routes used by local authorities and housing associations.

The projects required organisations within the supply chain delivering the work to provide training to existing and new staff to comply with PAS2035/2030. Most of the organisations interviewed recruiting new staff and providing training. However, no evidence was collected from the qualitative interviews as to whether there were equity considerations in hiring decisions or the selection of individuals to receive training. Some of the organisations reported providing the same training for all members of staff, or for entire teams within the organisation.

10.6 Exploring value for money of the programmes

Delivery of the projects within the SHDF(D) and WHR programmes has taken place within a context of considerable national and global economic challenges. This has affected the real costs for retrofit activities compared to what was anticipated in the project applications. Therefore, the costs per activity, output and outcomes achieved were higher than was anticipated at the start of the project. Most of these cost increases were due to factors outside the control of the programmes (for example supply chain and labour supply challenges), although some factors internal to the programmes (e.g. the timelines of the programmes, the parallel delivery of the projects accessing the same material and equipment supply chains, and delivery inefficiencies within projects) also had an effect.

There is evidence that the programmes have delivered most of the outcomes for residents anticipated and some for participating companies; however, neither are to the scale initially intended and the sustainability of the benefits to participating companies has not been possible to assess within the timeframe of this evaluation.

There is also strong evidence that the programmes have generated learning for DESNZ, local authorities and businesses supplying retrofit activities. It has not been possible to quantify these learning outcomes. This presents a challenge for assessing the effectiveness of the programmes as the value of the lessons learned will not be realised until future delivery of retrofit programmes has taken place.

This publication is available from: www.gov.uk/government/publications/whole-house-retrofit-and-social-housing-decarbonisation-fund-demonstrator-joint-process-evaluation

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