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CLIENT REPORT

Northern Ireland Evaluation of Energy Efficiency Schemes

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1. Executive Summary

1.1. Aims and Objectives

The aim of this work was to evaluate the performance of the Department for Communities Affordable Warmth (AWS) and Boiler Replacement (BRS) Schemes. Following the methodology established in previous scheme evaluation work, BRE has performed improvement modelling to simulate the effect of installing improvement measures through the 2020/21 and 2021/22 AWS and BRS and quantified the associated energy savings using the SAP (Standard Assessment Procedure) 2012 methodology.

Initially, a base position was established for each case improved through the grant schemes and BRE's SAP model was run to determine the SAP rating of each dwelling prior to any improvements being installed. The base inputs were then altered to simulate the installation of eligible improvement measures, and the model re-run to establish a 'post-improvement' position. The 'pre-improvement' and 'post-improvement' model runs were then compared to quantify the associated SAP rating increase, energy savings and CO₂ savings.

For this evaluation, the findings are based on the set of 'realistic' modelling assumptions which were derived in the previous scheme evaluation and are deemed to represent the most robust pre- and post-improvement positions for each dwelling, given the grant scheme measures that are installed.

1.2. Key Findings

When looking at cases across both the AWS and BRS, over 10,000 improvement measures have been installed across 7,928 cases. This includes 4,048 improvement measures installed through the AWS and 3,880 boiler upgrades performed as part of the BRS. Under the AWS, heating system upgrades were the most common measure installed, followed by upgrading windows and installing loft insulation (Figure E1).

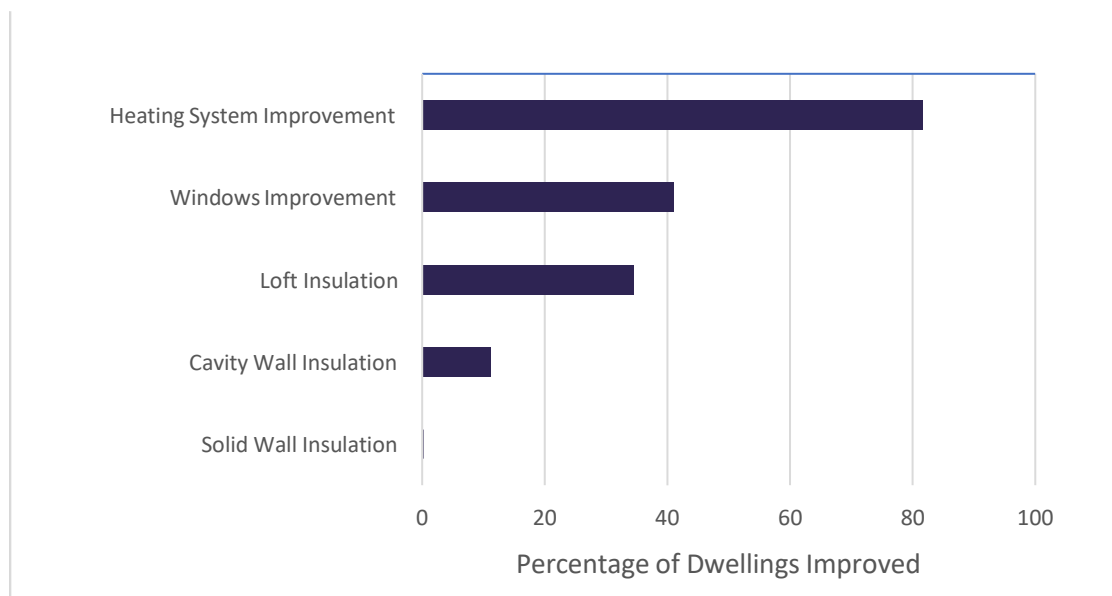


Figure E1. Percentage of dwellings receiving a grant that have received each improvement measure, under the AWS

When considering improvement measures from the Affordable Warmth Scheme, the average SAP rating increased by 13 SAP points (Table E1), rising from a mean SAP rating of 52 in the pre-improvement position, to 65 in the post-improvement position. The average modelled annual reduction in energy consumption was

5,701 kWh / year, which equated to an average energy bill saving of £364 per year and an average reduction in CO₂ emissions of 2.17 tonnes per year. The total annual energy savings achieved through the AWS was 23.1 GWh, with a total energy cost saving of £1.5 million / year and a total reduction in CO₂ emissions of 8.8 thousand tonnes per year.

Table E1. Average SAP improvement, energy and CO₂ savings achieved through the AWS

AWS	Average (mean)	Total
SAP rating improvement	13	
Energy Consumption Savings	5,701 kWh / year	23.1 GWh / year
Energy Cost Savings	£ 364 / year	£ 1.5 million / year
CO ₂ Savings	2.17 tonnes / year	8.8 thousand tonnes / year

Measures installed through the Boiler Replacement Scheme resulted in an average SAP rating increase of 7 points. The average modelled annual reduction in energy consumption was 2,309 kWh following improvement measures being installed, which equated to an average energy bill saving of £203 per year and an average reduction in CO₂ emissions of 1.2 tonnes per year. The total annual energy saving achieved through the BRS was 9.0 GWh, with a total energy cost saving of £0.8 million / year and a total reduction in CO₂ emissions of 4.8 thousand tonnes per year (Table E2).

Table E2. Total energy consumption, cost and CO₂ savings achieved through the BRS

BRS	Average (mean)	Total
SAP rating improvement	7	
Energy Consumption Savings	2,309 kWh / year	9.0 GWh / year
Energy Cost Savings	203 (£ / year	0.8 million £ / year
CO ₂ Savings	1.2 tonnes / year	4.8 thousand tonnes / year

Measures installed through the Affordable Warmth Scheme resulted in a higher SAP improvement, on average, compared to the Boiler Replacement Scheme (an increase of 13 SAP points compared to 7). Both the total and mean energy and CO₂ savings were also higher for cases improved through the Affordable Warmth Scheme compared to the Boiler Replacement Scheme. The greater savings associated with the AWS were due to a wider range of measures being installed to eligible dwellings, as well as modelled pre-improvement SAP ratings being lower, on average, than cases improved through the BRS. For example, households living in dwellings in the least efficient EER bands of F and G in the main received a package of 2 or 3 improvement measures; for the dwellings in the worst performing band G, this resulted in an average S A P rating increase of 43 points and for those in band F an average SAP increase of 23 points was achieved. Almost all the dwellings in these bands received a heating system upgrade, in combination with either a windows replacement or loft insulation upgrade.

1.3. Conclusion

Compared with the previous evaluation of scheme data from 2018/19 and 2019/20 the average SAP improvement across all cases was similar; for the Affordable Warmth Scheme an average increase of 16 SAP points was estimated for the 2018-20 schemes, compared with an average increase of 13 SAP points for the

current evaluation. The estimated mean energy consumption and fuel cost savings are correspondingly lower for the current data compared with the previous evaluation. The total annual energy consumption savings, total annual energy cost savings and total annual CO₂ savings are estimated to be lower for 2020-2022 compared with 2018-2020 due to the reduction in numbers of improvement measures installed.

For the Boiler Replacement Scheme, both the current and the previous 2018-2020 scheme data resulted in an average increase of 7 SAP points. Correspondingly, very similar average savings for energy consumption, energy cost savings and CO₂ savings were seen. The total annual energy consumption savings, total annual energy cost savings and total annual CO₂ savings are estimated to be lower for 2020-2022 compared with 2018-2020 due to the lower number of boiler upgrades carried out.

A significant factor governing the potential SAP rating increase is the starting EER band prior to any improvements being installed. These least efficient dwellings are typically the older building stock with a solid wall construction, which are generally more difficult and expensive to insulate than cavity walled homes. However, as this evaluation shows, when heating improvements are applied in combination with other fabric improvements a significant improvement in the energy efficiency rating can be achieved. For dwellings starting with an EER band E it would be reasonable to expect an average increase of around 15 SAP points.

2. Introduction

This report summarises the results of modelling work performed by BRE to evaluate the performance of the Northern Ireland 2020/21 and 2021/22 Affordable Warmth Scheme (AWS) and Boiler Replacement Scheme (BRS). Both the AWS and BRS offer grants to households to help with the installation of energy improvement measures.

Background - AWS

The Affordable Warmth (AW) Scheme commenced in April 2015. In the 8 years to March 2022 the scheme has so far assisted 22,522 homes and grant aided 41,175 measures with a value of £97,494 million to date.

The AWS targets low income households and provides them with a range of heating and insulation measures to improve the thermal efficiency of their home. The energy efficiency improvement measures are specifically designed for the needs of each individual home to provide the best possible and most complete outcome for the householders. The ultimate goal of the fuel poverty measures provided by the Department for Communities is to raise the SAP ratings of these fuel poor households to a level which will provide a warm, comfortable home to improve their thermal comfort and protect them from fuel price fluctuations thus alleviating the health impacts of fuel poverty.

Affordable Warmth measures are only available to private sector households e.g. owner occupiers and private sector tenants where the landlord is registered with the Department for Communities' Landlord Registration Scheme.

The AWS is administered by the Housing Executive in partnership with local Councils. It is an area based targeted scheme for households with a total gross annual income of less than £23,000. The AWS aims to provide whole-house improvement packages up to £7,500 (or £10,000 solid wall properties) for the following measures in priority order:

- Cavity wall insulation
- Loft insulation
- Draught-proofing
- First time or upgraded heating systems and controls
- single glazed windows to PVC Double glazing.

Background - BRS

The Boiler Replacement (BR) Scheme was launched by the Department for Communities in May 2012. The Boiler Replacement Scheme has so far assisted 41,613 homes and in 10 years has invested over £23 million to March 2022.

The Boiler Replacement Scheme offers owner occupied households with an income of up to £40,000 a grant of up to £1,000 towards replacing an inefficient domestic boiler (over 15 years old) with a new one and heating controls.

In order to evaluate the performance of the AWS and BRS, BRE has performed improvement modelling, following the methodology developed for the 2018/19 and 2019/20 scheme evaluation, to simulate the effect of installing energy efficiency measures on cases improved through the grant schemes. This has been quantified in terms of the increase to the dwelling's SAP rating, and the savings to energy consumption, energy bills and CO₂ emissions.



This review covers work done under the two schemes in 2020/21 and 2021/22 and marked as completed at the point of data delivery to BRE.

Of note, AWS referrals and completions being evaluated during this period would include those households impacted by government restrictions as a result of the global pandemic. Councils were not able to make site visits to customer homes and there was a requirement on Councils to prioritise only those referrals without an operational heating system, during the first lockdown period.

Households also experienced delays in sourcing a contractor to complete the works therefore resulting in some households cancelling other measures approved by the scheme.

3. Methodology

In order to evaluate the performance of the Affordable Warmth and Boiler Replacement grant schemes, it is necessary to estimate the energy performance of the dwellings helped by the schemes both before and after improvement. This has been conducted using the Government's SAP (Standard Assessment Procedure) energy modelling methodology¹. When interpreting the results presented here, it is important to consider that the energy use, energy costs, and carbon dioxide emissions savings are based on the assumptions built into the SAP methodology. SAP does not attempt to replicate actual behaviour of the occupying household, rather it uses standardised assumptions that permit comparisons between two dwellings regardless of their occupants or location for example.

For existing dwellings, SAP calculations are performed according to the methodology presented in the Reduced Data SAP (RdSAP) documentation². This methodology specifies a list of inputs required and permitted values for those inputs. These are then used to infer values for SAP inputs where they cannot be ascertained directly. An example of this is the U-value of a wall. This cannot usually be measured directly for an existing dwelling and therefore the U-value is inferred based on the dwelling age, the wall type and any applied insulation. Once all inputs (observed and inferred) are in place a full SAP calculation can be performed for that dwelling.

NIHE provided data for each dwelling benefitting from either scheme. The data included details of the measures applied, as well as basic information about the dwelling in its pre-improvement state. The information provided did not include all the required inputs to fully satisfy the RdSAP methodology, however the previous scheme evaluation had developed an inference procedure using dwelling archetypes and this was utilised in this evaluation, enabling a SAP calculation to be performed for each dwelling both before and after the application of any improvement measures.

3.1. Dwelling Archetype creation

Dwelling archetypes were developed using data from the 2016 Northern Ireland House Condition Survey (NIHCS), to inform the geometric inputs and fabric heat loss values used within the improvement modelling. Each case in the AWS and BRS dataset was able to be assigned to a dwelling archetype, based on the dwelling type recorded by the surveyor. The dimensions and fabric heat loss values associated with that archetype were then used as inputs into the BRE SAP model where needed. For more information on the use of dwelling archetypes as modelling inputs, and the dimensions and fabric heat loss values associated with each archetype, see Appendix A.

3.2. Assessment of improvement measures

For each case that received an improvement measure under the AWS or BRS scheme, data were typically available on the associated dwelling characteristics (e.g. dwelling type, age, wall type), the pre-improvement position of some building elements (e.g. current levels of loft insulation) and the energy improvement measures that were installed through each scheme. These data were analysed and a list of measures which could be modelled under the SAP methodology was compiled. These improvement measures, alongside the dwelling characteristics, were used as key inputs in the data modelling and helped to inform the pre- and post-improvement position of each case.

Appendix B lists the improvement measures that have been modelled under each scheme, as well as the assumptions used in the derivation of the pre- and post-improvement modelling positions.

¹ SAP 2012: https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf

² RdSAP v9.93, Appendix S: https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-9.93/RdSAP_2012_9.93.pdf

3.3. Data Modelling

BRE's SAP model was used to quantify the energy savings associated with improvements installed through the AWS and BRS. This is a proprietary model which has been developed to simulate the effect of installing energy efficiency improvement measures in dwellings. The model allows for a SAP rating to be calculated despite having fewer inputs than would normally be required for a full SAP calculation, by combining dimensions and fabric heat loss information from the dwelling archetypes with information on the dwelling collected through the grant schemes.

Initially, a base position was established for each case in the AWS and BRS datasets, using the dwelling characteristics and dimensions data defined in the previous stages. Each case was run through BRE's SAP model to determine the SAP rating of the dwelling prior to any improvements being installed. The base inputs were then altered to simulate the installation of any eligible improvement measures, and the SAP model re-run to establish a 'post-improvement' position. The 'pre-improvement' and 'post-improvement' model outputs were then compared to quantify the associated SAP rating increase, cost, energy, and CO₂ savings.

For certain grant scheme measures, uncertainty exists around how pre- and post-improvement positions should be derived, predominantly surrounding the heating efficiencies and level of heating controls associated with heating system upgrades. The same assumptions that were developed for the previous evaluation work were followed to provide consistency in the methodology across the years. A combination of RdSAP imputations and data extracted from the 2016 NIHCS were used to determine the most realistic pre- and post-improvement positions, given the nature of the specific measure being applied. The main findings presented throughout this report are based on these assumptions.

4. Findings

4.1. Affordable Warmth Scheme

4.1.1. Number of improvements

As part of the AWS 6,830 improvements were installed in total to 4,048 dwellings; 82% of dwellings received an upgrade to their heating system and / or controls, 41% received double glazing and / or draughtproofing of windows, 35% received loft insulation, 11% received cavity wall insulation, and less than 1% received solid wall insulation³ (Figure 1).

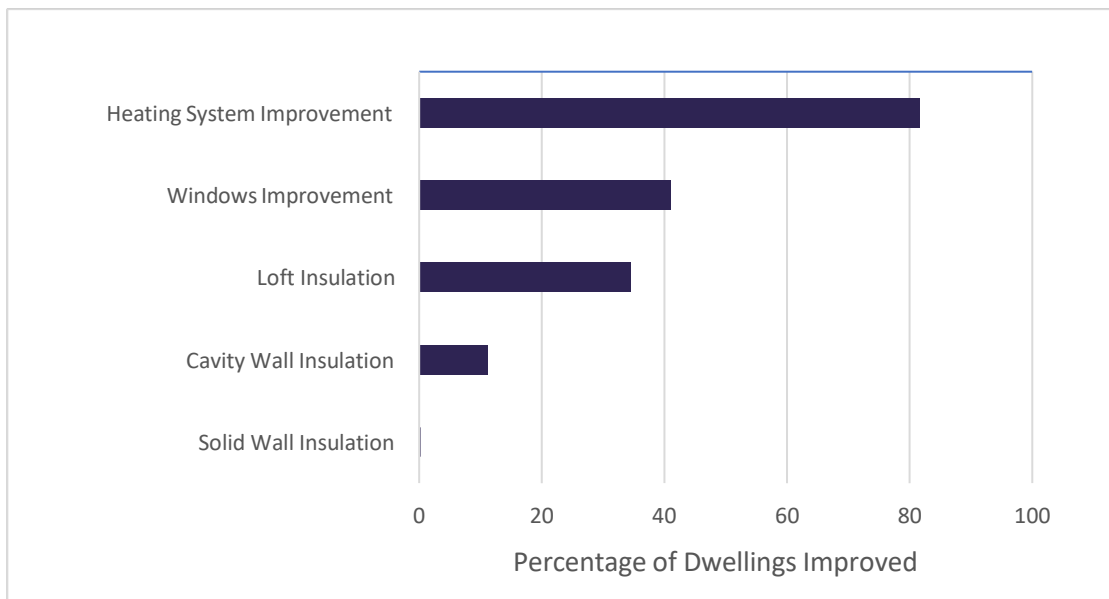


Figure 1. Percentage of improved dwellings receiving each improvement measure through the AWS

When considering the number of improvements applied to each dwelling, the pre-improvement Energy Efficiency Rating (EER) band⁴ of the modelled case has a direct impact and Table 1 shows how the number of improvements applied to a dwelling tends to increase as energy efficiency of the dwelling in its pre-improved state decreases.

Table 1. Percentage of dwellings receiving a given number of improvements through the AWS, split by pre-improvement EER band

Pre-improvement EER band	Number of improvements			
	1	2	3	4+
C	77%	23%	0%	0%
D	56%	37%	7%	1%

³ Only 9 dwellings were recommended a solid wall insulation measure in the combined 2020/21 and 2021/22 AWS data.

⁴ Energy efficiency rating bands are defined by the SAP rating according to Table 14 of SAP 2012. Dwellings in EER band A are highly energy efficient, with energy efficiency decreasing through to EER band G, which represents highly inefficient dwellings.

E	37%	44%	17%	2%
F & G	38%	45%	15%	2%

4.1.2. Impact of improvement measures on SAP ratings

Installing all eligible improvements recorded as part of AWS resulted in an increase to the SAP rating of participating dwellings by an average of 13 SAP points (Table 2). This takes the average SAP rating from 52 (EER band E) prior to any improvements, up to 65 (EER band D) in the post-improvement position.

Table 2. Average SAP rating increase achieved through the AWS

Mean pre-improvement SAP rating	Mean post-improvement SAP rating	Mean SAP increase
52	65	13

One of the most notable drivers behind the SAP improvement achieved through installing efficiency measures is the modelled EER band of each case, prior to any measures being installed. Table 3 shows that the highest SAP increases are achieved for cases which are modelled to have low pre-improvement EER bands. Cases rated band F or G, prior to any improvement measures being installed, achieve an average SAP rating improvement of 23 and 43 SAP points, respectively. Almost all the dwellings in these bands received a heating system upgrade, in combination with either a windows replacement or loft insulation upgrade. Conversely, cases rated band C prior to any improvements only achieve an average increase of 2 SAP points. This is in part due to the higher number of improvement measures installed in the worst performing dwellings but also that these dwellings typically required both a fabric improvement such as loft or cavity wall insulation, and a heating improvement.

Table 3. Average SAP rating increase achieved through AWS, by pre-improvement EER band

Pre-improvement EER band	Sample size	Mean pre-improvement SAP rating	Mean post-improvement SAP rating	Mean SAP increase
C	56	70	72	2
D	1757	59	67	8
E	1656	50	64	15
F	561	34	57	23
G	18	14	57	43
All Cases	4048	52	65	13

Figure 2 shows the percentage of cases which achieve banded SAP improvements, based on the pre-improvement EER band of the dwelling. Over 53% and 88% of dwellings with a pre-improvement EER band of F and G respectively, achieved an increase of over 24 SAP points through installing AWS measures. Conversely, 93% of dwellings rated band C prior to any improvements achieve an increase of under 5 SAP points.

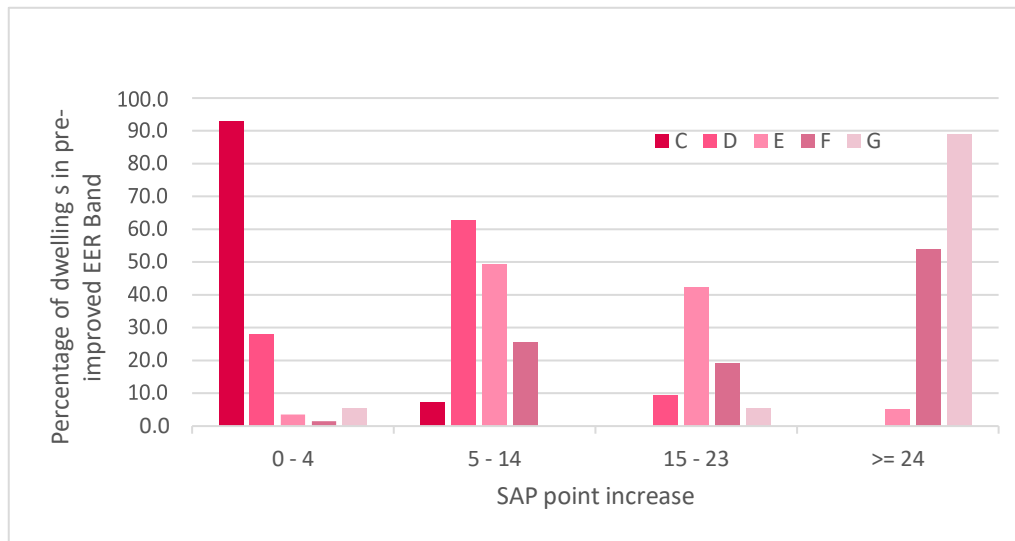


Figure 2. Percentage of AWS cases achieving banded SAP increase, split by pre-improvement EER band

4.1.3. Impact of improvement measures on energy and CO₂ savings

Installing improvement measures as part of the AWS results in an average annual energy saving of 5,701 kWh and an average reduction in energy bills of £364 per year (Table 4). This equates to a total annual energy saving of 23.07GWh. AWS improvements result in an average reduction of CO₂ emissions by 2.17 tonnes per year, and a total annual CO₂ emission reduction of 8,784 tonnes.

Table 4. Average and total energy consumption, cost and CO₂ savings achieved through the AWS

	Mean Annual Savings	Total Annual Savings
Energy Consumption (kWh)	5,701	23,076,914
Energy Cost (£)	364	1,472,015
CO ₂ Emissions (tonnes)	2.17	8,784

As with the SAP rating, the pre-improvement EER band has a marked impact on the energy and CO₂ savings that can be achieved through the installation of AWS improvement measures (Table 5). E and F rated dwellings achieve higher average savings in energy consumption, bills and CO₂ emissions, than dwellings with an EER band C. It is noted that although the G rated dwellings achieve an average energy cost saving of £1,303, the average energy consumption for these dwellings increased. These cases had no heating system pre-improvement (and were therefore imputed electric room heaters in the SAP methodology); they received a gas/oil central heating system under the AWS scheme which results in a higher energy consumption, but at a lower fuel tariff.

Table 5. Average energy consumption, cost and CO₂ savings achieved through the AWS, split by pre-improvement EER band

Pre-improvement EER band	Mean energy consumption (kWh /year)	Mean energy cost savings (£ / year)	Mean CO ₂ savings (tonnes / year)
C	1,497	53	0.33

D	3,968	233	1.35
E	6,241	390	2.38
F	10,143	695	4.24
G	-180	1,303	4.39
Total	5,701	364	2.17

4.2. Boiler Replacement Scheme

4.2.1. Number of improvements

A total of 3,880 dwellings received a new boiler as part of the BRS; 80% of the boilers being replaced were oil boilers, 19% gas boilers and 1% LPG boilers. Of the dwellings improved as part of this scheme, 67% of dwellings received gas boilers, 32% received oil boilers and 1% received LPG boilers. The majority of dwellings that used gas or LPG remained on the same fuel following their boiler upgrade (Table 6), whereas those dwellings using oil as their pre-improvement heating fuel were split between receiving gas and oil (60% and 40% respectively).

Table 6. Percentage of installed boilers on each fuel post-improvement by the fuel used pre-improvement

Pre-improvement Fuel	Post-improvement Fuel		
	Gas	LPG	Oil
Gas	>99	-	<1
LPG	12	76	12
Oil	60	<1	40
Any	67	1	32

4.2.2. Impact of improvement measures on SAP ratings

On average, upgrading a dwelling's heating system through the BRS resulted in a SAP rating increase of 7 SAP points (Table 7), from 65 (EER equivalent band D) in the pre-improvement position, to 72 (EER equivalent band C) in the post-improvement position.

Table 7. Average SAP rating increase achieved through the BRS

Mean pre-improvement SAP rating	Mean post-improvement SAP rating	Mean SAP increase
65	72	7

Generally, it is difficult for cases to achieve a SAP rating increase of more than 14 SAP points through the BRS (fewer than 1% of cases), due to just one improvement measure being installed in the dwelling (Table 8). Where cases have seen a significant increase to the dwelling's SAP rating, this is due to the boiler being upgraded from an expensive heating fuel (LPG) to a cheaper heating fuel (Natural (mains) Gas or Oil). As SAP is cost based, the fuel prices function as a major factor in the SAP rating of a dwelling, and therefore a switch from expensive to cheaper fuels can have a large impact on the change to a dwelling's SAP rating. To achieve larger increases to SAP ratings overall, boiler upgrades would have to be installed alongside fabric insulation measures, as is the protocol for the Affordable Warmth Scheme.

Table 8. Banded SAP rating increase achieved through the BRS

Banded SAP increase	Frequency	Percent
1 - 4	1,972	51%
5 - 14	1,894	49%
15 - 23	7	<1%
>= 24	7	<1%
Total	3,880	100%

4.2.3. Impact of improvement measures on energy and CO₂ savings

Upgrading boilers through the Boiler Replacement Scheme results in an average modelled annual energy saving of 2,309 kWh and an average reduction in energy bills of £203 per year (Table 9). This equates to a total annual energy saving of 9 GWh. BRS upgrades result in an average reduction in CO₂ emissions of 1.2 tonnes per year, and a total annual CO₂ reduction of almost 5,000 tonnes per year.

Table 9. Mean and total energy consumption, cost and CO₂ savings achieved through the BRS

	Mean Annual Savings	Total Annual Savings
Energy Consumption (kWh)	2,309	8.9 million
Energy Cost (£)	203	0.8 million
CO ₂ Emissions (tonnes)	1.2	4.7 thousand

4.3. All dwellings

When looking at cases across both the AWS and BRS, over 10,000 improvement measures have been installed across 7,928 dwellings. This results in an increase to the average SAP rating of 10 SAP points, rising from a SAP rating of 58 in the pre-improvement position, to 68 in the post-improvement position (Table 10). Measures installed through the AWS result in a higher SAP increase, on average, compared to upgrades performed through the BRS (an increase of 13 SAP points compared to 7).

Table 10. Average SAP rating increase achieved through the AWS and BRS

Scheme	Mean pre-improvement SAP rating	Mean post-improvement SAP rating	Mean SAP improvement
AWS	52	65	13
BRS	65	72	7
<i>All Cases</i>	<i>58</i>	<i>68</i>	<i>10</i>

Across all cases, the average modelled reduction in energy consumption was 4,041 kWh per year following improvement measures being installed, which equates to an average energy bill saving of £285 per year. Installing improvement measures across both schemes results in an average reduction in CO₂ emission of 1.71 tonnes per year and a total reduction of 13.5 thousand tonnes per year (Tables 11 and 12).

Table 11. Average energy consumption, cost and CO₂ savings achieved through the AWS and BRS

Scheme	Mean Energy Consumption Savings (kWh/year)	Mean Energy Cost Savings (£ / year)	Mean CO ₂ Savings (tonnes / year)
AWS	5,701	364	2.17
BRS	2,309	203	1.23
<i>All Cases</i>	<i>4,041</i>	<i>285</i>	<i>1.71</i>

Table 12. Total energy consumption, cost and CO₂ savings achieved through the AWS and BRS

Scheme	Total Energy Consumption Savings (GWh/year)	Total Energy Cost Savings (million £ / year)	Total CO ₂ Savings (thousand tonnes / year)
AWS	23.1	1.5	8.8
BRS	9.0	0.8	4.8
<i>All Cases</i>	<i>32.0</i>	<i>2.3</i>	<i>13.5</i>

The total energy, energy cost and CO₂ savings are higher for cases improved through the AWS. This is due to much higher average savings being achieved through the AWS, because of the wider range of measures installed.

5. Conclusion and Discussion

5.1. Quantifying improvement in SAP

An average increase of 13 SAP points is expected to have occurred through measures installed as part of the AWS and 10 SAP points through measures installed by the BRS.

The current evaluation of the 2020/21 and 2021/22 scheme data was based on fewer dwellings undergoing improvements compared with the previous evaluation of scheme data from 2018/19 and 2019/20. In the current evaluation using 2020/21 and 2021/22 data, after removing duplicate records from the dataset, and records where no applicable improvements had been added, there were 4,048 cases improved under the AWS and 3,880 cases improved as part of the BRS, giving a total of 7,928 cases. These numbers were lower than in the previous schemes, which had a total of 10,439 cases, of which 5,213 cases were improved under the AWS and 5,226 cases were improved under the BRS. Very few dwellings (only 9) received the solid wall insulation measure under the most recent scheme, compared with 54 dwellings under the previous scheme.

Figure 3 shows the proportion of dwellings that changed SAP Band rating as a result of the improvements installed under AWS. After the improvements were carried out, 31% of dwellings in band D, 26% of dwellings in band E and 10% of dwellings in bands F & G improved to band C. For those pre-improvement F & G rated banded dwellings, 50% were improved to a band D, 40% were improved to band E and 1% of the dwellings remained in the same band.

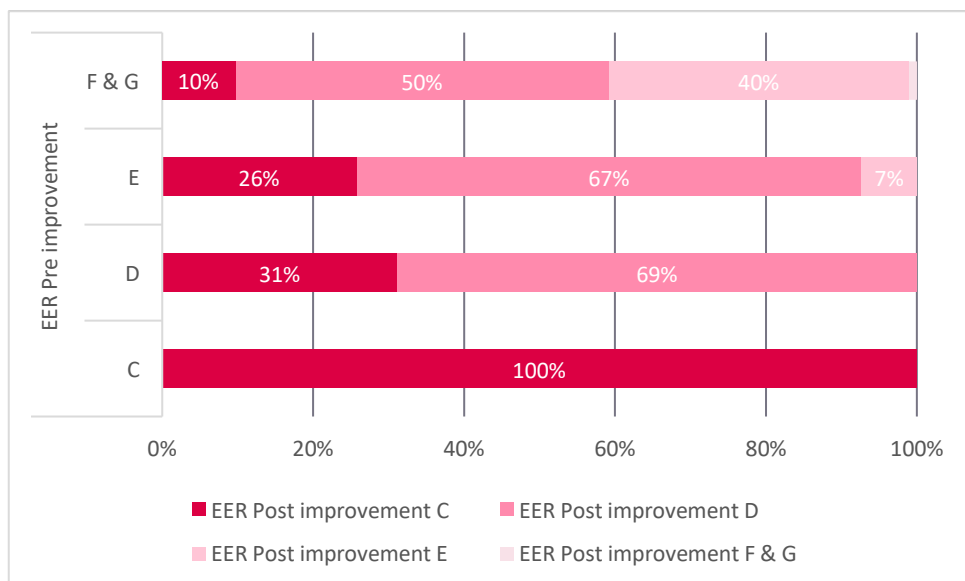


Figure 3. Percentage of AWS cases changing EPC band after improvements

A significant factor governing the potential SAP rating increase is the starting EER band prior to any improvements being installed. These least efficient dwellings are typically the older building stock with a solid wall construction, which are generally more difficult and expensive to insulate than cavity walled homes. However, as this evaluation shows, when heating improvements are applied in combination with other fabric improvements a significant improvement in the energy efficiency rating can be achieved. For dwellings starting with an EER band E it would be reasonable to expect an average increase of around 15 SAP points.

5.2. Strengths and weaknesses

It is important that the findings of this report are considered within the context of the data modelling approach taken, both in terms of the assumptions applied during the data translation phase, as well as the underlying modelling methodology followed.

BRE has performed an RdSAP calculation for each case in the grant scheme dataset as provided by NIHE, using our proprietary SAP model. The use of SAP provides a robust calculation framework, which is consistent with the longitudinal monitoring of energy efficiency across the UK performed by National Governments. It is however worth noting that SAP applies standardised assumptions around how occupants heat their home, weather conditions, and the fuel prices applied within the modelling. Actual energy consumption and householders fuel bills are therefore likely to deviate from the modelled outputs and will be highly dependent on occupant behaviour.

A full set of input data typically required to perform an RdSAP calculation was not available for this grant scheme evaluation. The 2021-22 AWS dataset had been extended to include data on internal floor area, for which there was a value recorded for 76% of the dwellings in that dataset. However no floor area data was available for the 2020-21 AWS data so for this evaluation, the data translation phase of this work continued to utilise dimensions data associated with dwelling archetypes (derived using the 2016 NIHCS data) in combination with information on grant scheme measures installed. A comparison of the average recorded and archetype floor areas by dwelling type was made using the data available, and it was seen that for flats and bungalows, the mean floor area measured was within 10% of the archetype floor area. There was a larger deviation seen for houses, particularly detached houses, and so the use of dwelling archetypes with 'typical' dimensions and heat-loss parameters applied to each case means that granularity within the data outputs is likely to be lost. Whilst this is not expected to impact the accuracy modelled energy savings on average, it may lead to the cases with highest and lowest energy savings being unrepresented. Data provided through the grant scheme was generally comprehensive enough to inform the derivation of required input datasets. However, assumptions were applied throughout the modelling where imputations were required.

Appendix A. Dwelling Archetypes

A full set of input data typically required to perform an RdSAP calculation was not available for this grant scheme evaluation. Therefore, the data translation phase of this work involved utilising dimensions data associated with dwelling archetypes (derived using the 2016 NIHCS data) in combination with information on grant scheme measures installed. The use of dwelling archetypes means that 'typical' dimensions and heat-loss parameters are applied to each case and therefore granularity within the data outputs is likely to be lost. Whilst this is not expected to impact the accuracy modelled energy savings on average, it may lead to the cases with highest and lowest energy savings being unrepresented.

The 2016 Northern Ireland House Condition Survey (NIHCS) has been used to determine the average dimensions and fabric heat loss parameters associated with each dwelling archetype identified from the grant scheme datasets.

Cases in the AWS and BRS were matched to a dwelling archetype and the associated dimensions data (Table A1) were used as an input into the BRE SAP model. For example, any case identified as a detached house was assumed to have a ground floor area of 98.6m² and a total wall area of 132.8m². More generic dwelling archetypes have been developed, for when there is no detailed information on the build type of the dwelling contained within the grant scheme datasets (i.e. House, Bungalow, Flat). This includes an 'Unknown' archetype, which simply uses the average dimensions and fabric heat loss parameters of the NI housing stock.

Table A1. Dimensions inputs associated with each dwelling archetype

Dwelling Type	Number of Storeys	Total Floor Area (m ²)	Ground Floor Area (m ²)	Roof Area (m ²)	Wall Area (m ²)	Party Wall Area (m ²)	Window Area (m ²)	External Door Area (m ²)	Internal Door Area (m ²)
End-terraced House	2	85.9	43.0	45.2	80.2	34.8	16.4	4.0	0.0
Mid-terraced House	2	82.0	40.2	43.3	51.1	68.4	14.1	4.1	0.0
Semi-detached House	2	98.2	50.6	58.4	76.9	35.2	20.0	4.4	0.0
Detached House	2	1871.8	98.6	117.3	132.8	NA	38.0	5.9	0.0
Attached Bungalow	1	63.0	63.0	63.0	45.1	18.5	11.7	3.9	0.0
Detached Bungalow	1	118.3	118.3	118.1	85.8	NA	26.0	5.0	0.0
Ground Floor Flat	1	60.9	60.1	60.3	43.4	7.0	5.9	0.0	1.9
Mid Floor Flat	1	64.9	64.9	64.9	31.6	2.2	6.2	0.0	1.9
Top Floor Flat	1	64.3	58.1	61.8	43.0	7.2	7.1	0.0	1.9

House	2	114.2	59.4	68.0	85.0	35.3	22.6	4.7	0.0
Bungalow	1	98.4	98.4	98.4	71.2	6.7	20.9	4.6	0.0
Flat	1	62.9	60.2	61.7	41.1	6.2	6.4	0.0	1.9
Unknown	2	107.3	68.0	74.2	78.9	27.1	21.1	4.5	0.0

Where RdSAP could not be used to impute fabric heat loss parameters, Table A2 was used to determine the values used within the modelling, based on the dwelling archetype. This is mainly relevant where key building characteristics were unknown (e.g. dwelling age, wall type and glazing type), meaning that the RdSAP imputation methodology could not be followed.

Table A2. Fabric heat loss parameters associated with each dwelling archetype

Dwelling Type	Wall U-value (W/m ² K)	Window U-value (W/m ² K)	Floor U-value (W/m ² K)	Roof U-value (W/m ² K)	Loft insulation thickness (mm)
End-terraced House	0.84	2.51	0.64	0.36	169
Mid-terraced House	0.89	2.51	0.53	0.38	169
Semi-detached House	0.73	2.51	0.58	0.35	172
Detached House	0.73	2.64	0.54	0.36	169
Attached Bungalow	0.67	2.42	0.58	0.28	199
Detached Bungalow	0.72	2.62	0.57	0.32	181
Ground Floor Flat	0.72	2.41	0.53	NA	NA
Mid Floor Flat	0.72	2.58	0.46	NA	NA
Top Floor Flat	0.67	2.51	0.54	0.36	173
House	0.79	2.54	0.56	0.36	170
Bungalow	0.70	2.55	0.58	0.30	188
Flat	0.70	2.48	0.52	0.36	173
Unknown	0.77	2.54	0.56	0.35	174

Appendix B. Modelling Assumptions Used

Data provided through the grant scheme was generally comprehensive enough to inform the derivation of required input datasets. However, assumptions were applied throughout the modelling where imputations were required.

5.3. Affordable Warmth Scheme

The AWS encompasses a multitude of improvement measures that can be installed in eligible dwellings. For the grant scheme evaluation modelling, a number of these improvement measures have been modelled, to quantify the energy savings associated with installing applicable measures. Measures excluded from the analysis are those that have no impact on the SAP rating of a dwelling, and those where the pre- and post-position were unable to be imputed sufficiently based on the data available.

For cases collected using the current AWS data format, information was provided on the characteristics of the dwelling prior to any improvement measures being installed (e.g. loft insulation thickness, wall type, glazing type, heating fuel), and used to determine the pre-improvement modelling position. Measure codes were used to determine the post-improvement position, as specified in Table B1.

Table B1. Simulated improvements for the Affordable Warmth Scheme

Measure Type	Measure Codes	Description	Pre-position	Post-position
Loft insulation	100	Providing 100 mm insulation	As recorded in dataset	Current loft ins + 100mm mineral wool
	150	Providing 150 mm insulation	As recorded in dataset	Current loft ins + 150mm mineral wool
	200	Providing 200 mm insulation	As recorded in dataset	Current loft ins + 200mm mineral wool
	300	Providing 300 mm insulation	As recorded in dataset	Current loft ins + 300mm mineral wool
CWI	FFI	CWI to uninsulated cavity	As recorded in dataset	Cavity insulated
	TOP	CWI top-up	As recorded in dataset	Cavity insulated
SWI	PSW	SWI	As recorded in dataset	Solid - wall insulated
Windows	PVC, RGU, RG2	Double glazing	As recorded in dataset	Double glazed, Post 2006
Heating Type	NG1, NG2, NG3	Upgrade heating system to gas	Imputed based on existing fuel	Condensing gas boiler
	OI1, OI2, OI3, OI4	Upgrade heating system to oil	Imputed based on existing fuel	Condensing oil boiler

	ESH	Upgrade heating system to storage heater	Imputed based on existing fuel	High heat retention storage heater
Heating Controls	NG1, NG2, OI1, OI2	Boiler replacement with new controls	No heating controls ¹	Programmer, roomstat & TRVs
	NG3, OI3, OI4	Boiler replacement – renew controls	Programmer & roomstat ¹	Programmer, roomstat & TRVs
	ESH	Upgrade heating system to storage heater	Imputed based on existing heating system	Controls for HHR storage heaters

¹ Pre-position heating controls are applied if a boiler is present prior to the heating upgrade. Otherwise, default controls from Table B5 are assumed.

5.4. Boiler Replacement Scheme

Only heating upgrades are included as part of the BRS. Measure codes in the BRS dataset (Table B2) are used to determine the post-improvement position of the heating system for each case, and the current heating fuel specified in the dataset is used to determine the pre-improvement heating system, using the fuel lookup in Table B3.

Table B2. Simulated improvements for the Boiler Replacement Scheme

Measure Type	Measure Codes	Description	Pre-position	Post-position
Heating Type	A	Natural gas with full controls	Imputed based on fuel	Condensing gas boiler
	G	Natural gas	Imputed based on fuel	Condensing gas boiler
	N	Natural gas with new controls	Imputed based on fuel	Condensing gas boiler
	B	Oil with minimum controls	Imputed based on fuel	Condensing oil boiler
	C	Oil with dual controls	Imputed based on fuel	Condensing oil boiler
	O	Oil	Imputed based on fuel	Condensing oil boiler
	L	LPG	Imputed based on fuel	Condensing LPG boiler
	P	LPG with minimum controls	Imputed based on fuel	Condensing LPG boiler
	G	Natural gas	Programmer, roomstat and TRVs	
	O	Oil		
	L	LPG		

Heating Controls	N	Natural gas with new controls	Programmer and roomstat	Programmer, roomstat and TRVs
	B	Oil with minimum controls		
	P	LPG with minimum controls		
	A	Natural gas with full controls		
	C	Oil with full controls		

5.5. Default heating efficiencies and controls

Where a case is eligible for a heating upgrade, the heating type assigned to the dwelling and its associated heating efficiency is improved from the pre-improvement to post-improvement position for the applicable fuels, to simulate the installation of a more efficient system (Table B3). For example, were a case on mains gas to be upgraded to a new gas boiler, the winter efficiency would improve from 78.22 in the pre-improvement position, to 93.1 in the post-improvement position. Where a case is not eligible for a heating upgrade, standard efficiencies are used within the modelling for both the pre- and post-improvement positions, determined by the heating fuel of the dwelling.

Table B3. Heating efficiencies applied during the improvement modelling

Fuel	Heating Type	Pre-improvement efficiency ¹		Standard / non-improved efficiency ²		Post improvement efficiency ³	
		Winter	Summer	Winter	Summer	Winter	Summer
Gas / LPG	Boiler	78.22	68.45	87.47	79.17	93.1	81.4
Oil	Boiler	85.37	73.66	86.06	74.44	93.1	81.4
Solid Fuel ⁴	Room heater	65		65		-	
Standard electric ⁵	Room heater	100		100		-	
Economy ^{7 6}	Storage Heater	100		100		100	

¹ Pre-improvement efficiencies are applied to the base model run if a dwelling is eligible for a heating measure and are derived from the NIHCS 2016 dataset, by taking the mean efficiency of all matched boilers older than 15 years.

² Standard efficiencies are used when a dwelling does not receive a heating measure for both the pre- and post-improvement positions. Standard efficiencies are derived from the NIHCS 2016 dataset, by taking the mean efficiency of all matched boilers between 5 and 15 years old.

³ Post-improvement efficiencies are applied to the improved model run if a dwelling is eligible for a heating measure. 92% is used as the annual post-improvement efficiency, with the winter and summer efficiencies derived from this.

⁴ Dwellings with solid fuel as the main heating fuel are assumed to use coal closed room heaters. Dwellings will never receive an improvement to a solid fuel system. Winter and summer efficiencies are not relevant to room heaters – instead, annual efficiencies are used.

⁵ Dwellings with standard electricity as the main heating fuel are assumed to use electric room heaters. Dwellings will never receive an improvement to a standard electric heating system.

⁶ Dwellings with economy 7 electricity as the main heating fuel are assumed to use storage heaters. Where a boiler upgrade specifies in the installation of storage heaters, it is assumed that high heat retention storage heaters are installed.

Default heating controls and cylinder details will be assumed throughout the modelling (Table B4), unless an improvement measure specifies otherwise (for example, where a heating measure which specifies the provision of heating controls is applicable, the pre-improvement heating controls listed in Tables B1 or B2 will be applied).

Table B4. Default heating controls and water heating parameters

Heating Type	Fuel	Heating Controls	Cylinder Insulation	Cylinder Thermostat
Boiler	All fuels	Programmer, thermostat and TRVs	Impute using RdSAP table S18 based on Age of dwelling	Present
Room heater	Solid fuel	No controls		
	Standard electric	Appliance Thermostats		
Storage heater (not HHR)	Economy 7	Automatic charge control		
Storage heater (HHR)	Economy 7	Controls for HHR storage heaters		