Cost of carbon savings in Northern Ireland's housing stock

Retrofitting energy efficiency measures to achieve EER Bands C and B: modelled using data from the Northern Ireland House Condition Survey 2016

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This report was produced by the Building Research Establishment (BRE) on behalf of the Northern Ireland Housing Executive. It is based on data collected through the 2016 Northern Ireland House Condition Survey (NIHCS) and estimates the cost of carbon savings in Northern Ireland's dwelling stock by improving the Energy Efficiency Rating (EER) to bands C and B.

Please note: It is not the intention of the Housing Executive to implement the findings of this report. The purpose is to contribute to and inform wider discussions, and to provide evidence of the impact of improving the dwelling stock in Northern Ireland.

For further information about the 'Cost of carbon savings in Northern Ireland's dwelling stock', or the House Condition Survey contact:

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Introduction

Housing policy throughout the UK has a focus on improving the energy efficiency of dwellings in the housing stock, in order to reduce fossil fuel emissions and help to ensure lower consumer energy bills. In the past, policy has been directed towards improving F & G rated dwellings. However, more recently, the UK Government has identified the need to improve the Energy Efficiency Rating (EER) band of dwellings in the stock to a band C and above. This report summarises the cost of improving dwellings in the Northern Ireland housing stock to an EER band C and B, and the associated energy savings that can be realised.

The Standard Assessment Procedure (SAP) is used as the underlying methodology to model energy efficiency improvements and quantify energy savings in this work. SAP has been developed by BRE[1] on behalf of Government, and uses an A to G banding system to rate the energy efficiency of a dwelling (where EER band A represents low energy costs i.e. the most efficient band, and EER band G represents high energy costs i.e. the least efficient band).

The main findings of this report follow the EPC improvement methodology set out in Appendix T of SAP 2012 (v9.93) [2], which is the same methodology used to suggest energy efficiency improvements on an Energy Performance Certificate (EPC). First, dwellings identified as being in an EER band of D or below have improvements simulated until they are improved to an EER band C. The process is then repeated with dwellings identified as being in an EER band of C or below having improvements simulated until they are improved to an EER band B. The cost of installing measures required to get to each band are then calculated, alongside the associated energy savings and reduction in SAP based running costs.

The improvement methodology recommended through Appendix T of SAP is just one of many pathways that can be taken to improve dwellings to a Band C and B. Some additional analysis has therefore been conducted to quantify the cost of improving dwellings through some alternative packages of improvement measures. These additional improvement scenarios have been specified by the Northern Ireland Housing Executive and encompass current thinking and policy considerations around the most feasible routes to improving the NI housing stock.

The user guide for this work, including the modelling methodology followed, is presented in Appendix A.

[1] BRE

[2] Information about SAP (including the updates to the model), is available in the NI House Condition Survey 2016 (Appendix H) NIHCS 2016

Key Findings

The total cost to improve the approximately 390,000 eligible dwellings in Northern Ireland to at least[3] a band C was £2.4 billion, with a mean cost of £6,200 per dwelling.

The overall impact of improving dwellings in Northern Ireland to Band C would be to provide mean energy cost savings of £500/year, mean CO_2 savings of 3.2 tonnes/year and a mean SAP rating increase of 14.

The total cost to improve the approximately 586,000 eligible dwellings in Northern Ireland to at least an EER band B was £9.2 billion, with a mean cost of £15,600 per dwelling.

The overall impact of improving dwellings in Northern Ireland to Band B would be to provide mean energy cost savings of £700/year, mean CO_2 savings of 3.7 tonnes/year and a mean SAP rating increase of 18.

Generally, traditional improvement measures, which focus on installing fabric insulation and upgrading heating systems, were sufficient to improve dwellings to an EER band C. To reach the target band B threshold however, further measures were required in the majority of cases. Specifically, the installation of photovoltaic (PV) panels was essential in improving a significant proportion of the stock to a band B.

Scenario modelling

The above findings follow the improvement methodology detailed in Appendix T of SAP, which represents one particular pathway for improving dwellings to a band C and above. In reality, it may be that a package of measures which deviates from the EPC methodology is most appropriate for improving the energy efficiency of dwellings. Therefore, some additional scenarios were analysed, to determine the cost of improving dwellings under alternative improvement pathways, using technologies likely to be employed in the short- and medium-term. Energy cost and CO_2 savings were also able to be estimated for each scenario, based on the calculated savings from the EPC improvement modelling.

Improving dwellings to a band C under the short-term scenario would cost a total of between £1.7 and 3.5 billion, with a mean installation cost of between £4,500 and £9,000. This compares with a total installation cost of between £1.9 and 5.2 billion for the medium-term scenario and a mean installation cost of between £4,900 and £13,400.

For both the short- and medium-term scenarios, improving dwellings to a Band C is estimated to achieve a mean energy cost saving of £540 and a mean CO_2 saving of 3.2 tonnes.

Improving dwellings to a band B under the short-term scenario would cost a total of between £6.2 and 10.7 billion, with a mean installation cost of between £8,300 and £14,400. This compares with a total installation cost of between £6.4 and 12.9 billion for the medium-term scenario and a mean installation cost of between £8,600 and £17,400.

For both the short- and medium-term scenarios, improving the 79% of dwellings able to reach a band B is estimated to achieve a mean energy cost saving of £700, and a mean CO_2 saving of 3.8 tonnes.

[3] A dwelling's EER band may be improved beyond the target band in some cases. For example, this may occur where a dwelling's EER rating is already close to band C, and a measure is installed with a high SAP improvement yield (e.g. SWI / PV), improving the dwelling beyond band C and into band B.

Cost to Improve Dwellings to EER Band C

BRE's EPC improvement model has been used to calculate the SAP 2012 rating for dwellings surveyed as part of the 2016 Northern Ireland House Condition Survey, in order to identify those with an EER band of D or lower. The model was also used to quantify the energy efficiency improvements realised through the installation of a range of improvement measures. Assigning costs to installed measures allows for an estimate of the total and average cost required to improve dwellings up to a given standard.

For each dwelling with an EER band of D or lower, improvement measures were simulated cumulatively, and the SAP rating recalculated after each improvement, until the dwelling reached the threshold for EER band C (a SAP rating of 68.5 or higher). The improvement measures, the order in which they are applied, and the associated costs of each measure follow the energy performance certificate (EPC) improvement methodology set out in SAP 2012. Appendix B lists the measures applied and the associated eligibility criteria. For more detail see Appendix T of SAP 2012[4].

Table 1 lists the improvement measures applied to eligible dwellings with an EER Band of D or lower from the NIHCS 2016 and the corresponding percentage of improved dwellings.

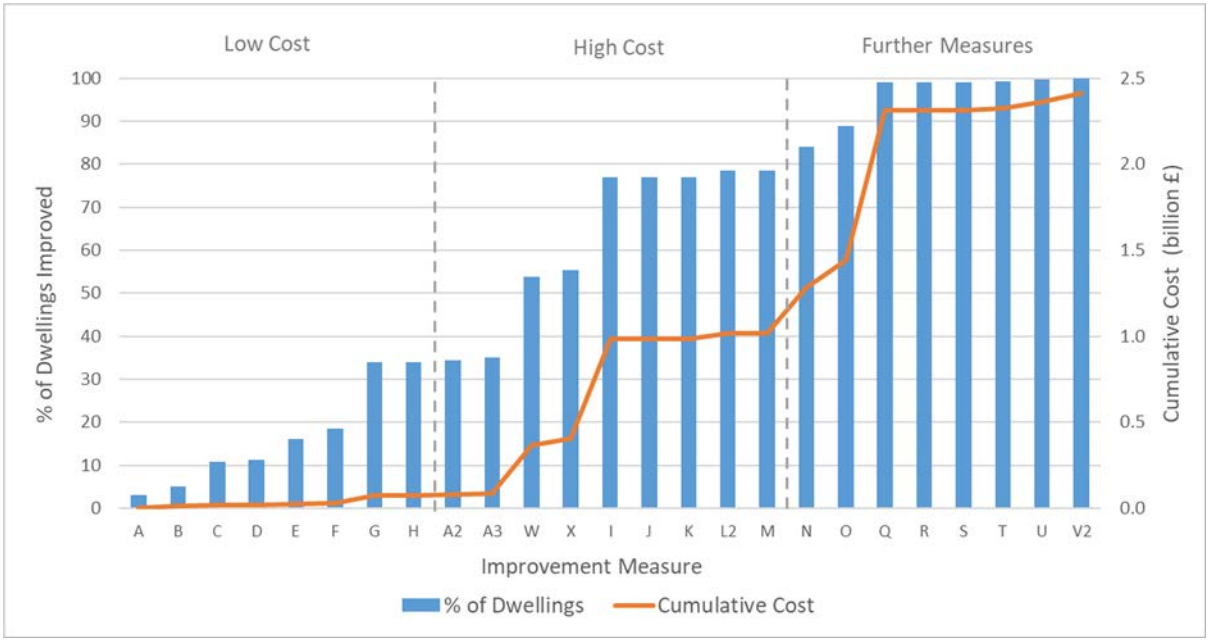
[4] BRE 2017. Appendix T: Improvement measures for Energy Performance Certificates, RdSAP 2012 v9.93. RdSAP 2012 version 9.93

Table 1: Improvement measures applied to dwellings with an EER band of D or lower.

Item	Measure	% of improved dwellings
Low Cost		
A	Loft insulation	42
B	Cavity wall insulation	16
C	Cylinder insulation	47
D	Draught proofing	10
E	Low energy lights	33
F	Heating controls - cylinder thermostat	25
G	Heating controls - wet central heating	63
High Cost		
A2	Flat roof insulation	1
A3	Roof room insulation	2
W1	Floor insulation - suspended floor	25
W2	Floor insulation - solid ground floor	38
X	Insulated doors	6
I	Upgrade boiler - same fuel	33
J	Upgrade boiler - low carbon central heating system	<1
K	Upgrade boiler - low carbon room heater	1
L2	Upgrade heating - storage heaters	2
Further measures		
O	Double glazed windows	6
O3	Glazing replacement	10
N	Solar water heating	16
Q	Solid wall insulation	10
T	Upgrade heating - condensing boiler	<1
U	Photovoltaics	1
V2	Wind turbine	<1

The total cost to improve the approximately 390,000 eligible dwellings in Northern Ireland to at least[5] a band C was £2.4 billion, with a mean cost of £6,200 per dwelling. Figure 1 shows the percentage of dwellings that have reached the EER band C threshold at each improvement measure stage, as well as the cumulative cost of implementing these measures[6].

Figure 1: Percentage of dwellings improved to EER band C with each improvement, and the associated cumulative cost.



Here, the improvement measures are broken down into three types; low cost, high cost and further measures, according to the EPC methodology (Appendix T). A to H are categorised as low cost measures, A2 to M as high cost measures and N to V2 as further measures. If only low cost measures were implemented, 35% of dwellings with an EER band of D or lower would be improved to the target threshold, with an associated cost of around £75.6 million. This accounts for 3% of the total cost to improve dwellings to an EER band C. Implementing both low and high cost measures would improve 81% of dwellings to the threshold, costing approximately £1 billion, which is 44% of the total cost. The further measures are required to improve the remaining 19% of dwellings to band C, but contribute 56% of the total cost.

Table 2 shows that 32% of dwellings with an EER band of D or below can be improved to at least a band C with up to two improvements. The mean cost to improve a dwelling to band C increases significantly when three or more improvement measures are required, compared to when only one or two measures

[5] A dwelling's EER band may be improved beyond a band C, to a band B, in some cases. For example, this may occur where a dwelling's EER rating is already close to the band C threshold, and a measure is installed with high SAP improvement yields (e.g. SWI / PV)

[6] For modelling purposes, measure O3 was combined with measure O. Measures W1 and W2 were also combined and are presented as measure W.

are required. The steep increase is likely due to the need for high cost and further measures to be installed in these dwellings.

Table 2: The number of improvement measures needed for each dwelling and the mean cost of applying that number of improvements.

No. of Improvements	% of Dwellings	Mean Cost (£)
1-2	32	1,300
3 plus	68	8,400

Table 3 shows the average annual energy cost and CO_2 savings achieved, split by the pre-improvement EER band of the dwelling. It also shows the average SAP rating increase for these dwellings following the installation of eligible improvement measures. Dwellings with a pre improvement EER band of F and G have the largest mean energy cost savings, and the largest mean CO_2 savings by a considerable amount.

Table 3: The mean energy cost savings, mean CO_2 savings and mean SAP rating increase of dwellings by pre-improvement EER band.

Pre-improvement EER Band	Mean Energy Cost Savings (£/yr)	Mean CO_2 Savings (kg/yr)	Mean SAP rating Increase
D	300	1,600	8
E	1,000	5,800	24
F & G	2,000	12,200	47
All	500	3,200	14

When analysing breakdown by tenure, 72% of improved dwellings were owner occupied, 21% private rented and 7% social rented (Figure 2). Owner occupied dwellings were the most expensive to improve to an EER band C, with a total installation cost of £1.9 billion and mean installation cost of £6,600 (Table 4).

Figure 2: Breakdown of dwellings with an EER band of D or lower by tenure.

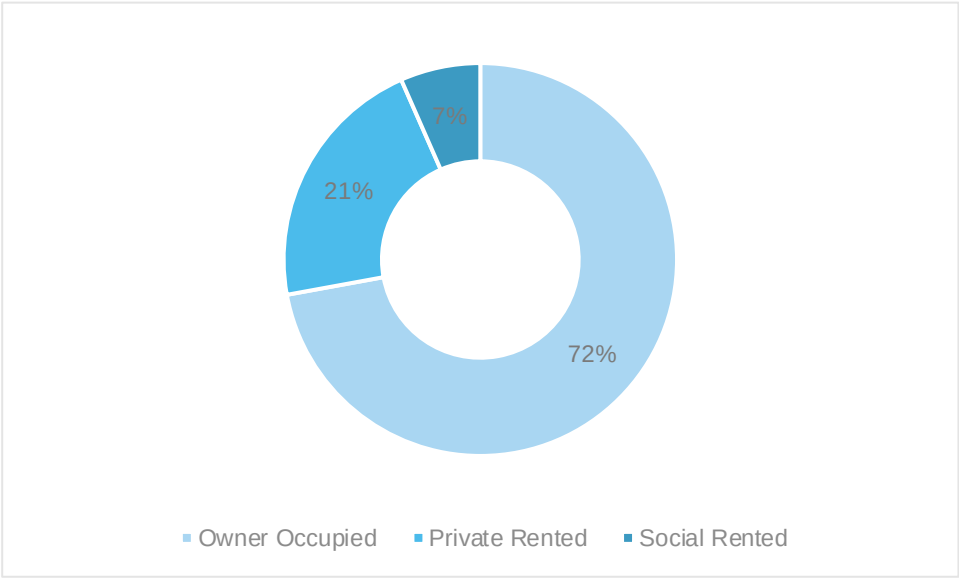


Table 4: The total and mean cost of improving dwellings to an EER band C by tenure.

Tenure	No. of Dwellings	% of Dwellings	Total Cost (billion £)	Mean Cost (£)
Owner Occupied	281,000	72	1.9	6,600
Private Rented	83,000	21	0.5	5,900
Social Rented	26,000	7	0.1	2,900

Of those dwellings with an EER band of D or lower, over 99% were able to be improved to an EER band C through the installation of improvements recommended by the EPC methodology. The remaining dwellings were not able to be improved to the target threshold, due to being ineligible for some of the measures required to improve their energy efficiency rating. This is not to say that it is impossible for these dwellings to reach a band C, just that the measures recommended through the EPC methodology are not sufficient to reach the target EER band.

Cost to Improve Dwellings to EER Band B

The same method was used to analyse the cost of improving dwellings identified as being in an EER band of C or below to an EER band B (SAP rating of 80.5 or higher). As with the band C modelling, improvement measures were applied cumulatively. The percentage of dwellings receiving each improvement are detailed in Table 5 below.

Table 5: Improvement measures applied to dwellings with an EER band of C or lower.

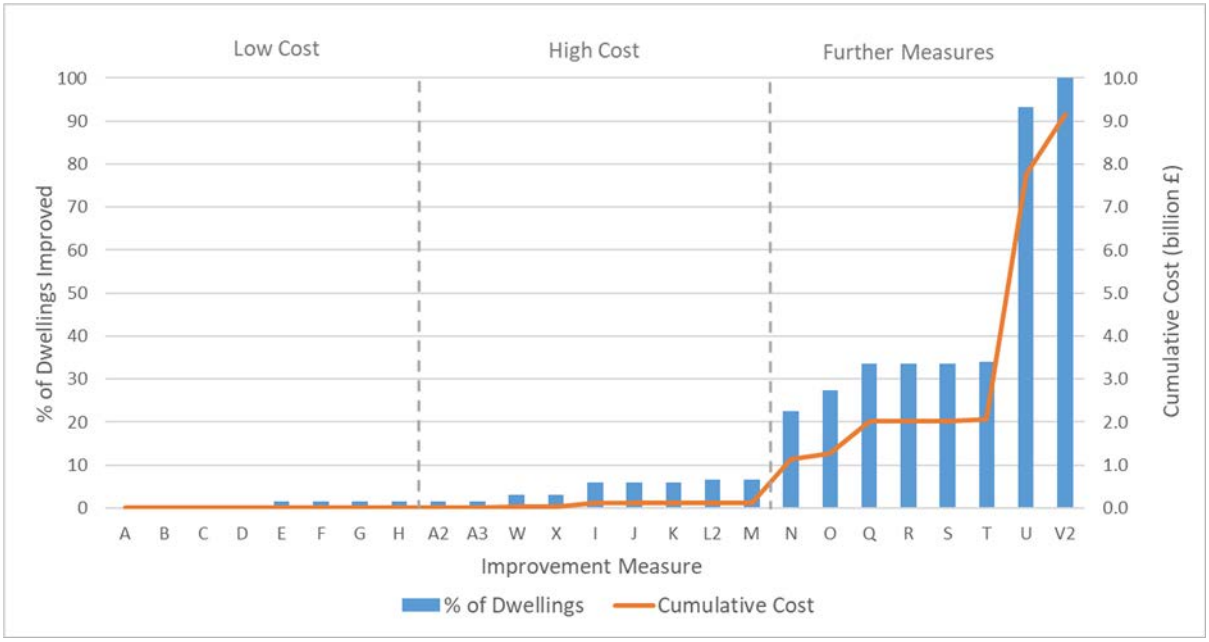
Item	Measure	% of improved dwellings
Low Cost		
A	Loft insulation	30
B	Cavity wall insulation	10
C	Cylinder insulation	30
D	Draught proofing	6
E	Low energy lights	41
F	Heating controls - cylinder thermostat	19
G	Heating controls - wet central heating	49
High Cost		
A2	Flat roof insulation	<1
A3	Roof room insulation	1
W1	Floor insulation - suspended floor	25
W2	Floor insulation - solid ground floor	47
X	Insulated doors	7
I	Upgrade boiler - same fuel	56
J	Upgrade boiler - low carbon central heating system	<1
K	Upgrade boiler - low carbon room heater	1
L2	Upgrade heating - storage heaters	2
Further Measures		
O	Double glazed windows	7
O3	Glazing replacement	53
N	Solar water heating	82
Q	Solid wall insulation	17
T	Upgrade heating - condensing boiler	1
U	Photovoltaics	62
V2	Wind turbine	7

The total cost to improve the approximately 586,000 eligible dwellings in Northern Ireland to at least[7] an EER band B was £9.2 billion, with a mean cost of £15,600 per dwelling. Figure 3 shows the cumulative

[7] A dwelling's EER band may be improved beyond a band B, to a band A, in some cases. For example, this may occur where a dwelling's EER rating is already close to band B, and a measure is installed with high SAP improvement yields (e.g. PV).

number and installation cost of the dwellings that have reached the EER band B threshold after each improvement measure.

Figure 3: Percentage of dwellings improved to EER band B with each improvement, and the associated cumulative cost.



Again, the improvement measures are broken down into three types; low cost, high cost and further measures, according to the EPC methodology (Appendix T). If only low cost measures were implemented, just 2% of dwellings with an EER band of C or lower would be improved, with an associated cost of around £2 million. Installing both low and high cost measures would improve just 7% of dwellings with an EER band of C or lower to the threshold, costing approximately £126 million. Further measures are required to improve the remaining 93% of dwellings with an EER band of C or lower, and account for 99% of the total cost.

Notably, figure 3 shows that traditional improvement measures which focus on fabric insulation and heating upgrades are not enough to improve the majority of the stock to a band B. It is not until renewable technologies, in the form of PV are installed (measure U), that a significant proportion of dwellings reach the target band B threshold.

Just 10% of dwellings with an EER band of C or lower can be improved with 1-2 improvement measures. The remaining 90% require at least three improvement measures to cross the band B threshold (compared to 63% of dwellings which require three or more improvements to reach band C). The mean installation cost increases significantly once three or more improvements are required, further highlighting the reliance on more expensive, renewable improvement measures being required to reach a band B.

Table 6: The number of improvement measures needed for each dwelling and the mean cost of that number of improvements.

No. of Improvements	% of Dwellings	Mean Cost (£)
1-2	10	3,900
3 plus	90	16,900

Table 7 shows the mean energy cost savings and the average CO_2 savings per year that can be achieved by improving dwellings to an EER band B. It also includes the mean SAP rating increase for these dwellings following improvement measures. As expected, mean energy cost savings, CO_2 savings and energy efficiency ratings are highest in the lower pre-improvement EER bands.

Table 7: The mean energy cost savings, mean CO_2 savings and mean SAP rating increase associated with improving dwellings to an EER band B.

Pre-improvement EER Band	Mean Energy Cost Savings (£/yr)	Mean CO_2 Savings (kg/yr)	Mean SAP rating Increase
C	400	1,900	10
D	800	4,200	22
E	1,400	7,900	37
F & G	2,300	13,300	58
All	700	3,700	18

Just over two thirds of dwellings (67%) with an EER band of C or lower were owner occupied (Figure 4). These had a total improvement cost of £6.4 billion and a mean cost of £16,300. Table 8 shows the numbers and costs of improving dwellings to at least a band B for private rented and social rented dwellings.

Figure 4: Breakdown of dwellings with an EER of band C or lower by tenure.

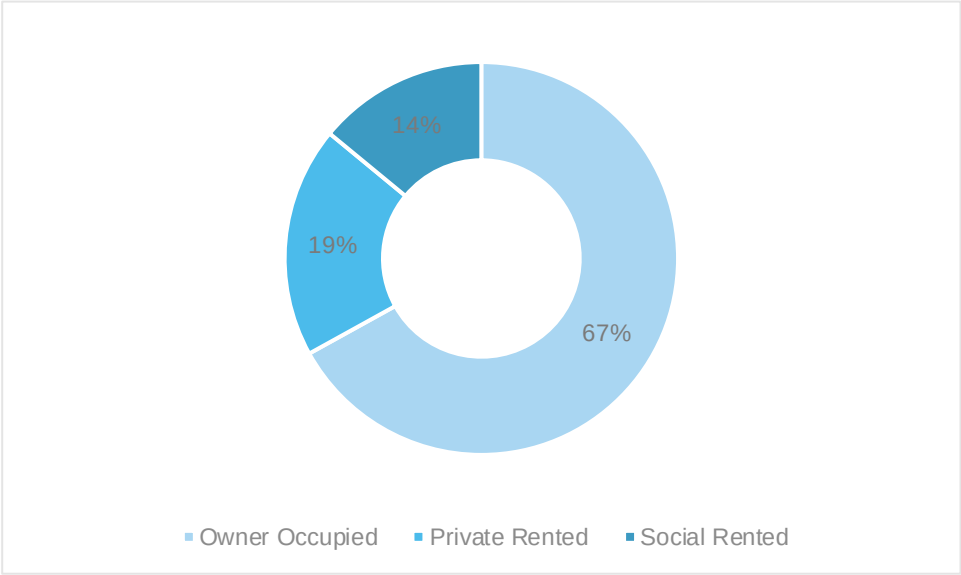


Table 8: The total and mean cost of improving dwellings to an EER band B by tenure.

Tenure	No. of Dwellings	% of Dwellings	Total Cost (billion £)	Mean Cost (£)
Owner Occupied	393,000	67	6.4	16,300
Private Rented	112,000	19	1.7	15,700
Social Rented	82,000	14	1	12,300

Of those dwellings with an EER band of C or lower, 21% were unable to be improved to an EER band B through the installation of improvements recommended by the EPC methodology. This figure is significantly higher than for the band C target threshold and highlights the requirement for higher standards of improvement measures to be applied when targeting the band B improvement threshold. This may be achieved through insulating the fabric of the dwelling to a higher level, installing low cost heating systems such as heat pumps with appropriate electricity tariffs, or utilising renewable technologies in the generation and storage of electricity.

Alternative Improvement Scenarios

The above findings follow the improvement methodology detailed in Appendix T of SAP, which represents one particular pathway for improving dwellings to a band C and above. In reality, it may be that a package of measures which deviates from the EPC methodology is most appropriate for improving the energy efficiency of dwellings. Therefore, some additional scenarios were analysed, to determine the cost of improving dwellings under alternative improvement pathways[8]. These scenarios have been created to reflect current thinking and policy considerations around the most feasible routes to improving the NI housing stock in the short- and medium- term. Two scenarios have been specified by NIHE (listed in Appendix C), each consisting of a package of improvement measures to improve dwellings to EER band C and band B. This creates 4 packages of measures in total:

- Measures likely to be installed in the short-term to improve dwellings to EER band C
- Measures likely to be installed in the short-term to improve dwellings to EER band B
- Measures likely to be installed in the medium-term to improve dwellings to EER band C
- Measures likely to be installed in the medium-term to improve dwellings to EER band B

Within the short-term and medium-term scenarios, the same improvement measures are specified in both the band C and band B packages, with the addition of PV being required to improve dwellings to a band B. This assumption matches the findings of the EPC modelling, which showed that PV was required in a significant proportion of dwellings to achieve an EER of band B or higher. It is assumed that the measures specified under each scenario are sufficient to improve each dwelling to the desired EER band. In some cases, dwellings may already have one or more of the energy efficiency measures specified within each improvement package, in which case they will only be flagged to receive the remaining measures that they are eligible for.

Cost of improvement under alternative scenarios

For each scenario, the number of dwellings applicable to receive at least one of the measures in the improvement package has been identified, and a cost to install applicable measures calculated. The eligibility criteria set out in Appendix C have been used to determine whether a household is eligible to receive each measure specified in the package and a range of installation costs have been provided, based on the notional PCDB costs used for the EPC modelling methodology. A range of costs has been presented to capture the uncertainty associated with applying the notional PCDB prices from equivalent Appendix T measures.

Table 9 shows the total number of dwellings eligible to receive at least one measure under each improvement scenario, alongside the mean and total cost of installation. Under both the short-term and medium-term scenarios, 100% of dwellings below a band C were eligible to receive at least one of the measures specified. Greater than 99% of dwellings were eligible to receive at least one of the measures specified to get to band B under the short-term scenario, and 100% under the medium-term (for both scenarios, the number of dwellings is the same when rounded to 3 significant figures).

[8] For more information see Appendix A: Strengths and weaknesses

Table 9: Mean and total cost of installing one or more measures under each scenario.

Scenario	Number of dwellings eligible (Thousands)	Mean cost of installation (£)	Total cost of installation (billion £)
Band C Short term	390	4,500 - 9,000	1.7 - 3.5
Band B Short term	740	8,300 - 14,400	6.2 - 10.7
Band C Medium term	390	4,900 - 13,400	1.9 - 5.2
Band B Medium term	740	8,600 - 17,400	6.4 - 12.9

Installing the measures specified in the short-term band C scenario to dwellings with an EER band of D or below would cost a total of between £1.7 and 3.5 billion, with a mean installation cost of between £4,500 and £9,000. This compares with a total installation cost of between £1.9 and 5.2 billion for the medium-term scenario and a mean installation cost of between £4,900 and £13,400. The higher cost to improve dwellings to a band C under the medium-term scenario is due to the inclusion of heat pumps as a heating upgrade measure (which have higher notional costs than the equivalent oil boilers installed under the short-term scenario), and the addition of low energy lighting as a measure in the improvement package.

Installing the measures specified in the short-term band B scenario to dwellings with an EER band of C or below would cost a total of between £6.2 and 10.7 billion, with a mean installation cost of between £8,300 and £14,400. This compares with a total installation cost of between £6.4 and 12.9 billion for the medium-term scenario and a mean installation cost of between £8,600 and £17,400. The higher costs to get to band B are associated with the addition of PV as an improvement measure, as well as an additional number of dwellings being improved (all those with an EER band of C). Again, the medium-term scenario results in higher costs than the short-term scenario, due to the inclusion of heat pumps and low energy lighting.

A further breakdown of the percentage of dwellings below the target EER band eligible for each improvement measure is detailed in table 10 and 11 for band C and band B scenarios respectively, alongside the total cost of improvement were eligible dwellings to receive each measure.

Table 10: Percentage of dwellings below band C eligible for each improvement measure as specified under the band C alternative scenarios, alongside the total cost of installation.

Measure	% Eligible	Total Installation Cost (million £)
Loft insulation	76	76.7 - 181
Cavity wall insulation	14	28.1 - 84.3
Solid wall insulation	23	359 - 1,260
Double glazing	79	486 - 827
Install / upgrade gas boiler	3	29.8 - 50.9
Install / upgrade oil boiler (short-term scenario only)	66	585 - 867
Install heat pump (medium-term scenario only)	66	771 - 2,570
Heating controls	94	128 - 165
Water cylinder thermostat	53	41.3 - 82.6
Water cylinder insulation	86	5.05 - 10.1
Low energy lighting (medium-term scenario only)	100*	1.9

*Actual value is 99.6%

See footnote for cavity wall insulation in table above[9]

Table 10 shows the proportion of dwellings eligible for each of the improvement measures specified under the band C short-term and medium-term scenarios. A high proportion of dwellings were eligible to receive heating controls (94%), cylinder insulation (86%) and double glazing (79%), while all dwellings received improvements to low energy lighting under the medium-term scenario. The installation of oil central heating, heat pumps and solid wall insulation had the highest associated total cost, despite not being the most frequently installed measures, due to a high notional installation cost per dwelling.

[9] The eligibility criteria for CWI under the alternative scenarios was a U-Value > 1W/m2k. This means that only uninsulated cavity wall dwellings built prior to 1978 are eligible (as building regulations specified better U-values for cavity dwellings after this date). The data indicates that even within this age bracket, many cavity dwellings have received retrofit insulation, and so the 14% figure reflects this.

Table 11: Percentage of dwellings eligible for each improvement measure as specified under the band B alternative scenarios, alongside the total cost of installation.

Measure	% Eligible	Total Installation Cost (million £)
Loft insulation	71	144 - 335
Cavity wall insulation	9	34.7 - 104
Solid wall insulation	14	431 - 1,510
Double glazing	73	771 - 1,270
Install / upgrade gas boiler	6	99.1 - 145
Install / upgrade oil boiler (short-term scenario only)	45	754 - 1,110
Install heat pump (medium-term scenario only)	45	996 - 3,320
Heating controls	91	238 - 306
Water cylinder thermostat	34	50.2 - 100
Water cylinder insulation	75	8.38 - 16.8
Low energy lighting (medium-term scenario only)	100	3.7
PV	98	3,630 - 5,810

Table 11 shows the proportion of dwellings eligible for each of the improvement measures specified under the band B short-term and medium-term scenarios. The majority of dwellings were eligible for PV (98%) and heating controls (91%), and as with the Band C scenarios, all dwellings were eligible to receive low energy lighting in the medium-term. PV has the highest total cost associated with installation under the band B scenarios, due to the high number dwellings eligible to receive the measure, as well as a high notional installation cost per dwelling.

Estimated energy and CO_2 savings

The main findings have already calculated the SAP based running cost and CO_2 savings associated with improving each dwelling to a band C and/or B, and it is assumed that the same savings would be achievable through the alternative improvement scenarios. These savings should be considered estimates, as they are based on the improvement pathways assumed under the EPC modelling methodology. Energy cost and CO_2 savings associated with the alternative scenario packages may differ, especially where the scenarios specify installing a heating system which uses a different fuel to that recommended through an EPC assessment (such as electric heat pumps). It should be noted that a proportion of cases did not reach the threshold of an EER band C and/or B under the EPC modelling methodology, and therefore energy cost and CO_2 savings for these dwellings are not able to be attributed under the alternative scenarios. It may be possible for these dwellings to be improved through the installation of measures not included under the standard EPC methodology (such as those suggested under the improvement packages), but the associated savings are unknown for this work.

Table 12 shows the estimated energy cost and CO_2 savings achievable under each scenario, as modelled through the EPC improvement modelling, for dwellings identified as being able to reach the target EER band. The EPC modelling found that > 99% of dwellings with an EER band of D or below were able to be improved to a band C through the EPC methodology, and 79% of dwellings with a band C or below were able to be improved to a band B.

Table 12: Mean and total estimated energy and CO_2 savings under each scenario for dwellings able to reach the target band under EPC modelling.

Scenario	Mean estimated energy cost savings (£)	Mean estimated CO_2 savings (tonnes)	Total estimated energy cost savings (million £)	Total estimated CO_2 savings (million tonnes)
Band C (short- and medium- term)	540	3.2	212	1.2
Band B (short- and medium- term)	700	3.8	409	2.2

Improving dwellings to a band C under the short- and medium-term scenarios is estimated to achieve a mean energy cost saving of £540, a mean CO_2 saving of 3.2 tonnes, a total energy cost saving of £212 million, and a total CO_2 saving of 1.2 million tonnes. Improving the 79% of dwellings able to reach a band B under the short- and medium-term scenarios, is estimated to achieve a mean energy cost saving of £700, a mean CO_2 saving of 3.8 tonnes, a total energy cost saving of £409 million and a total CO_2 saving of 2.2 million tonnes.

Appendix A: User guide

Method

The 2016 NIHCS collected information on building characteristics for each dwelling sampled. The building characteristics are used as inputs for BRE's EPC improvement model which calculates a numeric SAP rating (1-100) for each dwelling, from which an Energy Efficiency Rating (EER) band (A-G) is assigned (Table 2).

Table A1: SAP Rating Bands

Rating	Band
G	1 to less than 20.5
F	Greater than or equal to 20.5 and less than 38.5
E	Greater than or equal to 38.5 and less than 54.5
D	Greater than or equal to 54.5 and less than 68.5
C	Greater than or equal to 68.5 and less than 80.5
B	Greater than or equal to 80.5 and less than 91.5
A	Greater than or equal to 91.5 or more

Cost to improve dwellings to an EER Band C and B

The work presented in this report concerns improving dwellings with an EER band of D or below to a band C, and improving dwellings with an EER band of C or below to a band B. Once dwellings with an EER band of below either a band C or B had been identified, improvement measures were simulated until dwellings reached the relevant SAP rating threshold (for band C the threshold is 68.5 and for band B the threshold is 80.5). The order in which improvement measures were simulated and the eligibility criteria used to determine whether a dwelling received each measure is specified in Appendix T of SAP 2012.

A SAP value was recalculated at each improvement stage and checked against the EER band threshold. If the SAP value had reached or exceeded the threshold, no more improvement measures were applied. If the threshold had not been reached, the next eligible improvement measure was applied and the SAP value recalculated. This process was repeated until each dwelling reached the required threshold for the target EER band.

Once all the necessary improvements needed for each dwelling were established, a cost of installing each improvement measure needed to reach the target EER band was calculated. Mean indicative costs from the Product Characteristics Database (PCDB) were applied for each improvement measure that a dwelling received, as is consistent with the methodology used for calculating the cost of improvements in EPCs. The total cost of improvement for each dwelling was calculated by summing the costs of all improvement measures a dwelling received.

Energy cost and CO_2 savings were also able to be calculated through the improvement modelling. SAP based running costs and CO_2 emissions were calculated for each dwelling prior to any improvements being simulated, and then re-calculated in the dwellings post-improvement state (once all measures required to improve the dwelling to an EER band C or B had been simulated). The difference between pre- and post-improvement energy and CO_2 metrics was then calculated to determine the savings achieved.

Alternative improvement scenarios

In addition to calculating the cost of improvement using the EPC improvement methodology, a number of alternative improvement scenarios have been specified by the NIHE. Four packages of improvement measures have been specified, representing alternative whole-house approaches that could be taken to improve dwellings to band C and band B. The measures included in each scenario, alongside the eligibility criteria and associated cost of installation are listed in Appendix C.

Under each improvement scenario, dwellings eligible to receive at least one installation measure were identified using dwelling characteristics modelled as part of the NIHCS 2016. A flag was created for each improvement measure that a dwelling was eligible for, and PCDB equivalent costs were assigned based on the measures flagged. For example, if under scenario 1, a dwelling was flagged as being eligible for cavity wall insulation and a cylinder thermostat, the cost for EPC measure B (CWI) and measure F (Cylinder thermostat) would be applied. For the alternative scenarios, a cost range was calculated for each measure, to represent the uncertainty associated with using cost equivalents, using the low and high costs included in the PCDB.

Energy modelling was not performed to quantify the exact energy and CO_2 savings that could be achieved through each improvement scenario. However, an estimation of savings was possible by attributing the savings calculated as part of the band C and band B modelling. For example, dwellings flagged as being eligible for the band B short- and medium-term scenarios, are assumed to achieve the energy and CO_2 savings as calculated as part of the 'Cost to improve dwellings to an EER band B' main findings.

Quality information

The quality assurance of this modelling work focused on ensuring that the translation of data inputs to simulate energy improvement measures was carried out robustly and appropriately, and that dwellings eligible for the alternative scenarios were flagged appropriately. The process of development, quality assurance and creation of results followed an internal procedure so the work undertaken could be reviewed and assessed by project managers.

Examples of the quality assurance undertaken to validate the cost to improve the SAP rating of dwellings in Northern Ireland processes and results included:

- Checking of transformations undertaken and mathematical formulae.
- Internal checks of data inputs to assure translation was completed correctly.
- Checks of correct units for calculations.
- Check correct and latest external data sources were used.
- Sense check of results.
- Internal review of results and reporting.

Surveyors working on the 2016 NIHCS received training and support to help ensure their collection of energy related data were consistent and robust. A re-fresher training session in 2016 explained the principles, how the form should be completed as well as conducting practical exercises with feedback sessions. While these measures ensure a good level of consistency in judgements, some surveyor variability is to be expected.

Strengths and weaknesses

Strengths

- This work uses data from the 2016 Northern Ireland House Condition Survey which has a number of processes in place to ensure the quality of the data.
- The model used SAP 2012 (RdSAP 9.93) which is the most up to date model available. This version updated the U-values for solid brick, stone and cavity walls to more accurately reflect their thermal performance. It also included an improvement to the way concrete walls were modelled.
- The work performed here utilises well established and robust models for applying the improvement scenarios outlined in Appendix T of SAP 2012, ensuring that the identification of eligible dwellings and the subsequent application of eligible improvements has been done accurately.

Weaknesses

- The size of the sample for the NI House Condition Survey 2016 was 3000 addresses. A weighting and grossing process translated the information gathered into figures that reflected the real world[10]. This provided robust data at Northern Ireland level.
- The energy cost and CO_2 savings attributed to the alternative scenario work should be considered estimates. Savings were derived by applying improvement measures in the order specified in the EPC improvement methodology – these measures will likely be different to the measures specified under each improvement package. As SAP is a cost-based indicator, it is reasonable to assume that similar energy cost savings will be achieved regardless of the route to the target EER band. However, depending on the heating fuels modelled and the split of end use energy consumption, CO_2 savings will differ.
- Cost equivalent installation prices have been applied to the alternative scenarios work, using the most appropriate measure from Appendix T of SAP 2012. A range of costs have been presented, using the 'Low' and 'High' costs from the Product Characteristics Database (PCDB) to reflect the uncertainty surrounding these figures.
- In terms of the alternative scenarios, it wasn't possible to determine whether dwellings would reach the target threshold through the agreed upon modelling approach (as no improvement modelling was performed for the alternate scenarios). Instead, the focus was on identifying how many dwellings would be applicable to each improvement scenario, and calculating the associated cost of installation (under the assumption that the specified scenarios would be enough to reach the target threshold). As the scenario measures are similar in scope to the EPC improvements, it's likely that a similar number of dwellings would be improved to the target EER bands. However, it is unknown to what extent deviations in eligibility criteria and improvement standards would affect the number of dwellings able to reach the target thresholds.

[10] Further information on the sampling, and weighting and grossing processes for the Northern Ireland House Condition Survey 2016 is available in the report NIHCS 2016

Appendix B: Improvement measures for EPCs

Table B1 shows the improvement measures considered for EPCs, the order in which they are implemented and the eligibility criteria.

Table B1: EPC improvement measures

Item	Measure	Considered when:	Recommended if:	Improve to:
A	Loft insulation	Pitched roof	<= 150mm	270mm
B	Cavity wall insulation	Unfilled cavity	U-value > 0.6	Filled cavity
C	Cylinder insulation	Cylinder present	<=25 foam, <80 jacket	80mm Jacket
D	Draught proofing	Always	<100% draught proof	100%
E	Low energy lights	Always	<100%	100%
F	Heating controls-Cylinder stat	Cylinder present	No cylinderstat	Cylinderstat
G	Heating controls-wet central heating	Wet central heating	< roomstat, programmer + TRVs	Roomstat, programmer + TRVs
H	Heating controls-warm air	Warm air	< roomstat + prog.	Roomstat + prog.
A2	Flat roof insulation	Flat roof	< 100mm	U-value = 0.18
A3	Roof room insulation	Roof rooms	U-value > 0.5	U-value = 0.18
W1	Floor insulation (suspended)	Suspended	As-built age band <=J Retrofit <= 50mm / U-value >0.5	U-value = 0.25
W2	Floor insulation (solid)	Solid and ground below	As-built age band <=J Retrofit <= 50mm / U-value >0.5	U-value = 0.25
X	Insulated doors	Door to outside	Uninsulated	U-value =1.5
I	Upgrade boiler, same fuel	Gas boiler LPG/oil boiler where gas not available	Non condensing, Range boiler	Condensing
J	Upgrade boiler, Biomass boiler	Solid fuel boiler	No mains gas	Manual feed biomass boiler
K	Upgrade boiler, Biomass room heater	Solid room heater / fire	No mains gas	Wood pellet stove with radiators
L2	Upgrade heating, Storage heaters	Old storage rads	No mains gas	High retention storage rads
M	Upgrade heating, Warm air unit	Warm air gas / lpg	Pre 1998	Non-condensing warm air unit
O3	Glazing replacement	Pre 2006 double glazed	< 80% post 2006	U-value = 1.6
N	Solar water heating	All	No SHW	SHW
O	Double glazed windows	Single glazing	<80% multiple glazed	U-value = 1.6
Q	Solid wall insulation	Solid brick	U-value > 0.6	Insulated solid
R	Upgrade boiler – Oil	Oil warm air	No mains gas	Condensing Oil Central Heating
S	Upgrade heating – gas fires	Gas fires	All	Condensing Central Heating

T	Upgrade heating – fuel switch	Non mains gas room heaters / non-condensing boilers)	Mains gas available	Condensing gas boiler
U	Photovoltaics	Not thatched roof	No PV	PV
V2	Wind turbine	Rural	No turbine	Turbine

Appendix C: Alternative Improvement Scenarios

This appendix presents some alternative pathways for improving the energy efficiency of dwellings in Northern Ireland. Table C1 lists the package of improvement measures suggested for improving dwellings to EER band C and B in the short-term, and Table C2 lists the measures suggested for improving dwellings to the same energy efficiency thresholds in the medium-term. Each measure listed in the packages below has been assigned the notional cost of an equivalent measure from Appendix T of SAP 2012. For both the short- and medium-term scenarios, the assumption is made that renewable technology (in the form of PV) is required to improve dwellings to a band B, on top of the measures required to get to band C.

Table C1: Pathways to band C / B in the short-term

Measure	Target EER Band	Recommended when:	Improve to:	Appendix T measure cost
Loft insulation	C / B	< 200mm mineral wool (U-value > 0.21 W/m^{2}K)	270mm mineral wool (U-value of 0.16 W/m^{2}K)	A / A2 / A3 (dependant of loft type)
Cavity wall insulation	C / B	Cavity wall with a U-value > 1.00 W/m^{2}K	Cavity insulated with U-value of 0.5W/m^{2}K	B
Solid wall insulation	C / B	Uninsulated solid wall	Insulated solid wall (U-value of 0.21 W/m^{2}K)	Q
Double glazing	C / B	Single glazing or pre-2002 double glazing (U-value >= 2.6 W/m^{2}K)	Modern double glazed windows (U-value of 1.4 W/m^{2}K)	O / O3 (dependant of current glazing)
Install / upgrade gas boiler	C / B	Mains gas is available. Boiler with an efficiency <80% or non-CH system	Modern gas boiler with efficiency >= 88%.	I / R / S / T (dependant on current system)
Install / upgrade oil boiler	C / B	Mains gas not available. Boiler with an efficiency <80% or non-CH system	Modern oil boiler with efficiency >= 88%.	I / R / S / T (dependant on current system)
Heating controls	C / B	Not full time and temperature zone control	Time and temperature zone control	G
Water cylinder thermostat	C / B	Cylinder stat not present	Cylinder stat present	F
Water cylinder insulation	C / B	Cylinder with less than 50mm factory insulation / 80 mm jacket insulation	Cylinder with 50mm factory insulation	C
PV	B only	No PV	PV	U

The improvements recommended under the medium-term scenarios focus on an increased level of fabric insulation and include the installation of low energy lighting and heat pumps in the measure packages. The eligibility criteria for measures common to both the short and medium-term scenarios has not changed, and therefore the number of eligible installations for these measures will be the same. However, the improved position has been altered for some measures, and this has resulted in a change to the cost of installation for cases eligible to receive a heat pump.

Table C2. Pathways to band C / B in the medium-term

Measure	Target EER Band	Recommended when:	Improve to:	Appendix T measure cost
Loft insulation	C / B	< 200mm mineral wool (U-value > 0.21 W/m^{2}K)	400mm mineral wool (U-value of 0.11 W/m^{2}K)	A / A2 / A3 (dependant of loft type)
Cavity wall insulation	C / B	Cavity wall with a U-value > 1.00 W/m^{2}K	Cavity insulated with U-value of 0.5W/m^{2}K	B
Solid wall insulation	C / B	Uninsulated solid wall	Insulated solid wall (U-value of 0.21 W/m^{2}K)	Q
Double glazing	C / B	Single glazing or pre-2002 double glazing (U-value >= 2.6 W/m^{2}K)	Modern triple glazed windows (U-value of 0.8 W/m^{2}K)	O / O3 (dependant of current glazing)
Install / upgrade gas boiler	C / B	Mains gas is available. Boiler with an efficiency <80% or non-CH system	Modern gas boiler with efficiency >= 88%.	I / R / S / T (dependant on current system)
Install heat pump	C / B	Mains gas not available. Boiler with an efficiency <80% or non-CH system	Heat pump	Z1 / Z2
Heating controls	C / B	Not full time and temperature zone control	Time and temperature zone control	G
Water cylinder thermostat	C / B	Cylinder stat not present	Cylinder stat present	F
Water cylinder insulation	C / B	Cylinder with less than 50mm factory insulation / 80 mm jacket insulation	Cylinder with 50mm factory insulation	C
Low energy lighting	C / B	< 100% LEL	100% LEL	E
PV	B only	No PV	PV	U

Report Ends