Department for
Business, Energy
& Industrial Strategy

WHAT DOES IT COST TO RETROFIT HOMES?

Updating the Cost Assumptions for BEIS's Energy Efficiency Modelling

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Executive summary

DECC wishes to update its assumptions about the cost of upgrading the energy efficiency of homes. CAR interviewed organisations carrying out energy improvements to homes, asking how much it actually costs to do the work. We also collected data from retailers about the current cost of energy efficiency measures – from insulation to LED lights.

This study set out to collect data on the actual cost of 18 measures intended to improve household energy efficiency. From wall and loft insulation to new boilers and double glazing, and from LED lights to draught-stripping, Cambridge Architectural Research compiled robust figures for the cost of carrying out different upgrades.

We identified 183 energy efficiency installers, plumbers and electricians, and 20 other organisations including large-scale retrofit contractors and housing associations with an interest in energy efficiency. We interviewed 52 of them from around England and Wales by telephone and gathered supplementary information by email where required. Some declined to be interviewed because they did not have cost data, but most of them had experience of more than one of the 18 upgrade measures, and the estimates of costs for more common measures are drawn from experience installing them on thousands of homes.

We also carried out a search of published literature about the costs of energy efficiency upgrades, including cost data from websites. We found 15 sources with some information about the cost of improving household energy efficiency.

Resource constraints prevented us from carrying out more interviews or more thorough literature searching (for example, using references from overseas). Larger sample sizes for the interviews would make the cost cited here more reliable, especially for more uncommon measures where we identified fewer interviewees. Consequently, these figures should be interpreted as *indicative* costs.

Wall Insulation

In total, 23 interviewees provided cost data for installing wall insulation, so there was considerable evidence to draw on. Unsurprisingly, interviewees gave a range of different costs for each of the wall insulation measures. For cavity wall insulation, the range was £5-£6 per square metre of wall, or £480 to £660 for a small semi-detached home (less than 80m^2). (Costs exclude VAT throughout.)

Solid wall costs were considerably higher, given the additional work involved in installing external wall insulation and rendering on top, or fitting internal insulation, applying plasterboard and redecorating for internal wall insulation. The range of costs for internal wall insulation was £55 to £140 per square metre of wall, or £5,000 to £10,400 for a small semi-, compared to

external wall insulation costs from £55to £180per square metre or £7,000 to £9,000 for a small semi-.

We also gathered costs for insulating party cavity walls: ranging from £25-£30 per square metre or £350 per home.

This is broadly consistent with cost data from the literature review, which cited costs ranging from £480 to £1400 per dwelling for cavity wall insulation, £6,800 to £15,000 per home for solid wall insulation, and £300-£350 per home for party cavity wall insulation. (The 'high' estimates from the literature for cavity- and solid-wall insulation are higher than those from installers, which may suggest some reduction in costs over time, since the literature was published.)

Loft Insulation

Again, many interviewees had hands-on experience of carrying out loft insulation work. Twenty-six of them had done this. Again, they offered a range of costs – from £10 to £20 per square metre or £180 to £610 per small semi-detached home for insulation installed at the joists. Differences were sometimes due to different insulation thicknesses, and whether the loft already had some insulation (by far the majority of lofts already have some insulation).

Costs for insulation at the rafters were considerably higher, at £20 to £40 per square metre, or £1,900 to £2,500 per small semi-detached home. Data on flat roof insulation was very limited, with only two interviewees providing cost data which suggested costs of £50 to £100 per square metre.

Again, this ties in well with literature sources, where the range given is from £185 to £670 for insulation installed at the joists (with one high cost cited for a 'hard to treat' loft, at £2,500).

Floor Insulation

Insulating the floor of a dwelling is less common. We spoke to five interviewees with experience of insulating suspended timber floors (underneath the floorboards), and three of these provided some cost data. (However, we were unable to interview organisations with experience of insulating solid floors.) For suspended floors, one interviewee suggested £750 per large semi-detached dwelling. Two interviewees provided estimates per square metre, ranging from £1 per square metre for material plus a fixed installation cost of around £550, to £95 per square metre in total.

How does this compare to past work from the literature looking at the cost of floor insulation? The figures quoted in the literature for insulating suspended timber floors were considerably higher: £3,500 to £8,300 per dwelling. The literature also provided data on solid floor insulation, ranging from £1,300 to £9,800.

Glazing

Installing double glazing is a very common energy efficiency upgrade, and we interviewed nine firms with experience of this measure. This means the figures collected are more reliable, and based on a large number of installations. Costs were commonly cited in terms of the cost per

window, but were also provided on a per home basis. They came out from £4,800 to £7,000 for a small semi-detached house with uPVC windows. Clearly, there are significant differences in quality between different types of double glazing, and interviewees said the costs for aluminium or timber frames might be up to double the cost of uPVC.

It was harder to get reliable cost data for secondary glazing – partly because this tends to be a DIY measure, not requiring professional installation. Typical costs were cited at £110 per square metre of glazing.

Literature sources provided indicative costs for replacement double glazing, but not the cost of replacing only the panes, or of secondary glazing. The costs offered for replacement double glazing were somewhat higher than our interviewees said: from £3,900 to £10,700.

Heating

We interviewed 13 companies with experience of installing boilers and heating systems. The costs provided for a replacement gas boiler in a small semi-detached home ranged from £1,600 to £4,000. Costs for a replacement oil boiler were higher, at £2,500 to £5,000.

Where a whole heating system needs to be replaced, costs were given of £2,100 to £5,500 for a small semi-detached home.

Costs cited for a cylinder jacket were much lower: £10-£20 for the jacket only, rising to £80-£90 including installation.

The boiler costs from interviewees were similar to those identified in past work: £1600 to £2400 for a replacement boiler, but with a higher upper limit. So too, the cost of a cylinder jacket was roughly consistent: £13-£40 in literature sources.

LEDs

We interviewed four contractors with experience of supplying LEDs. One gave costs for fittings, two gave costs for bulbs only, and the fourth provided costs per home. The DIY costs for bulbs only ranged from £2 to £20.40 per bulb, while the cost given for installing a dedicated LED fitting was £50. There was a strong consensus that the cost of bulbs is falling.

We also obtained bulb costs directly from four suppliers (actual ordering costs). These varied somewhat between different types of bulb and fitting (GU10, MR16, E27 or E14), but all types of bulb fell in the range £3.50 to £10 each, a narrower range of prices than the installers indicated. Two of the suppliers also offered bulk discounts (£10 for three B22s or three E27s).

These costs are remarkably similar to the cost of LEDs cited in the literature (remarkable because the literature sources appear to have captured the falling costs of LEDs even though some were written several years ago). Costs from £4.20 a bulb to £9.80 were given in the literature.

Draught-proofing

We were unable to identify any contractors with experience of installing draught-proofing materials. This is unsurprising, since draught-proofing is easy to fit and usually a DIY upgrade. Again, we obtained the cost to order from four DIY suppliers, which ranged from £7 to £9 for 6m^2 of window film, £7 to £10 for 10m of door or window seal, and £5 to £20 for a letterbox draught excluder. (Part of the variation in costs of letterbox excluders came from very different aesthetics and quality of manufacture.)

These figures are hard to compare with the costs given in literature about draught proofing, which tended to be presented as ‘whole home’ costs, and ranged from £85 to £275 per home. However, depending how far householders go in addressing draughts, these total costs are not unreasonable based on the materials cost.

Introduction

Purpose of the study

DECC commissioned Cambridge Architectural Research Ltd (CAR) to undertake a study to update DECC's assumptions about the costs of different energy efficiency interventions in existing homes. Prior to this study, the last time DECC reviewed its cost assumptions was in 2012. The time was right to review the assumptions again, after nearly three years of ECO support for interventions, and possible changes to costs resulting from product cost reductions and changes to the typical specifications used for different measures.

The study had the following aims:

- to review and collect data on current (2015/16) installed costs for a range of measures;
- to investigate how costs had changed over time, since 2000; and
- to consider key factors affecting costs, including economies of scale.

Scope of the study

The retrofit measures included within the scope of the study are shown in Table 1 below.

Table 1: Retrofit measures included in the study

Measure Type	Measure Sub-Type	Measure Detail
Fabric Insulation	Wall Insulation	Internal Wall Insulation External Wall Insulation Cavity Wall Insulation Party Cavity Wall Insulation
	Loft Insulation	Loft Insulation (Joists) Loft Insulation (Rafters) Flat Roof Insulation
	Floor Insulation	Underfloor Insulation
Glazing Upgrade		Replacement Double Glazing (panes and frames) Replacement Double Glazing (panes only, in existing frames) Secondary Glazing
Heating Upgrade		Gas Boiler Replacement Gas Central Heating Installation Oil Boiler Replacement Hot Water Cylinder Insulation (Jacket)
Other		LEDs Draught-stripping

1.1. As the costs of measures vary significantly depending on the characteristics of a home, were gathered for a range of house types identified by DECC as representative of typical existing homes in England. These house types were based on English Housing Survey and are summarised in

Table 2 below.

Table 2: House types included in the study

House type	Floor Area (m²)
Small flat	<54m²
Large flat	>54m²
Small mid-terrace house	< 76m²
Large mid-terrace house	> 76m²
Small semi-detached / end-terrace	< 80m²
Large semi-detached / end-terrace	> 80m²
Small detached house	< 117m²
Large detached house	> 117m²
Bungalow	Approx. 117m²

Interviewees were told the floor area of each house type and provided estimates of costs accordingly.

Methods

The methodology used for the study is summarised in

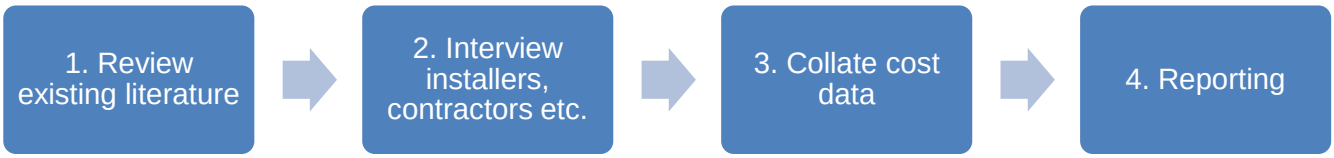

Figure 1 below.

Figure 1: Study approach

We carried out a literature review of reports exploring the costs of energy efficiency measures. This was based on key reports which DECC and CAR were aware of, internet searches, and recommendations from organisations contacted during the study. An additional internet-based search was also undertaken at a later stage, to investigate DIY measures where installers have limited involvement.

A range of organisations including installers, contractors, trade associations, manufacturers, procurement bodies and social housing providers were then contacted to request recent cost data for the range of measures included in the study and to gather information on factors affecting costs. Where they had information which could be shared, this was gathered through interviews or email correspondence.

We then collated cost data to provide a range of costs for each measure. The reliability of the data gathered was reviewed at this stage. Information on the impact of various factors affecting costs was included in the collated dataset (quantitative where possible, otherwise qualitative), and key assumptions were noted.

The findings from the work are set out in the following sections of this report.

Limitations of the study

Readers should note the following limitations of the study:

- Sample size: whilst we interviewed a fairly large number of organisations, the sample per measure is still relatively small due to the limited scope of this study. This is an important limitation and the data presented in the report should be treated with caution. It would be more robust if the project scope had been wider and a larger sample of interviewees could have been targeted for each measure. As explained in the 'Costs' section of this report below, it was particularly difficult to find interviewees for the following measures: party cavity wall insulation, flat roof insulation, floor insulation and replacement glass in existing frames. It was also difficult to find interviewees for secondary glazing, hot water cylinder jackets, LEDs and draught-proofing, but we supplemented interview data with DIY costs obtained via internet searches for these measures.
- Data quality: within the scope of the study it was not possible to verify all the cost data, and interviewees did not always provide complete information (for example, covering all house types or indicating inclusions/exclusions in the cost data).Interviewees commonly provided their own 'rule of thumb' estimates and it was hard to assess how consistent specifications used by different installers or contractors were (there may have been differences between the technical performance of measures installed by different interviewees). However, in terms of efficiency standards, given the timescales, the majority of interviewees were probably working to current Building Regulations and Green Deal/ECO specifications. They generally provided costs based on what they perceived to be a 'standard' or simple installation, or provided a low-high range of costs, and then commented on additional factors which would increase or decrease the costs.
- Influence of external factors: factors such as energy efficiency policy and schemes impact on costs. For example, the specifications set under schemes like the Green Deal and ECO help determine the costs of measures (e.g. it is currently common practice to avoid more expensive detailing when installing external wall insulation, or to avoid moving kitchen/bathroom fittings when installing internal wall insulation). Changes to policy or specifications would alter future costs, and in some cases this could have a significant effect.
- Focus on installed costs: it will obviously be important to consider other factors as well as installed costs in any assessment, such as energy savings and lifecycle costs of measures. For example, tightening standards would increase installed costs but would result in other benefits and may entail relatively small marginal cost increases compared with the avoided costs of replacing measures in ten years or so. Some interviewees noted that they have recently been upgrading wall insulation to standards going beyond the existing Building Regulations.

These limitations mean the costs reported in this study should be used and interpreted with care, and seen as *indicative* rather than definitive.

Literature Review

Introduction

We undertook a review of the literature on the costs of energy efficiency upgrades over the period February – March 2016, with the aim of identifying existing reports including relevant recent data on domestic retrofit costs. Literature was identified from a range of sources:

- Key online word searches e.g. “cost” & “domestic/home” & “retrofit”; “cost” & “energy efficiency” & “measures” & “domestic/home”;
- Recommendations from organisations contacted as part of the study;
- References found in the reports identified through the means above.

Reports with costings prior to 2010 were excluded (though sometimes the exact dates of costs were not provided in reports; in these cases the report date was used as the inclusion/exclusion date). The reports identified are shown in Appendix A.

Findings

We found cost data in 15 literature sources, and findings from the review are summarised in Table 3 on the following pages. Supporting tables are provided in Appendix A, including further information on the measures listed in Table 3 and on the data sources and assumptions used.

Table 3: Summary findings from Literature Review

Measure	Lowest cost/home	Mean cost/home	Highest cost/home
Internal Wall Insulation	£6,800	£7,900	£8,900
External Wall Insulation	£7,100	£11,800	£15,000
Cavity Wall Insulation	£480	£750	£1,400 (£2,500 hard-to-treat)
Party Cavity Wall Insulation	£300	£325	£350
Loft Insulation	£185	£450	£670 (£2,000 HTT)
Flat Roof Insulation	-	-	-
Underfloor Insulation	£3,500	£5,800	£8,300
Solid Floor Insulation	£1,300	£5,700	£9,800
Replacement Double Glazing (panes & frames)	£3,900	£6,400	£10,700
Replacement Double Glazing (panes only)	-	-	-
Secondary Glazing	-	-	-
Gas Boiler Replacement	£1,600	£2,000	£2,400
Gas Central Heating Installation	-	-	-
Heating controls	-	£450	-
Oil Boiler Replacement	-	-	-
Hot Water Cylinder Insulation (Jacket)	£13	£22	£40
LEDs	£4.20/bulb	£7/bulb	£9.80/bulb
Draught-stripping	£85	£180	£275

*All assuming a semi-detached home with a floor area of 90m^2, wall area of 60m^2, glazing ratio of 0.25. Assumes 150mm loft insulation. Costs include materials and installation but exclude VAT.

Costs

Organisations interviewed

We contacted a range of organisations including installers, contractors, trade associations, manufacturers, procurement bodies and social housing providers to request recent cost data and to gather information on factors affecting costs. In total, we contacted 203 organisations. Of these, 151declined to participate or ultimately were not able to provide data. There were various reasons for this: lack of available relevant data, lack of time or interest, and data confidentiality concerns.

Data confidentiality was a particular concern for larger organisations. The majority of the organisations contacted were installers (183); the rest were trade associations or societies (4); boiler manufacturers (4); insulation or window manufacturers (3); procurement organisations (3); registered social landlords (3); and large contractors (3). Organisations were identified in various ways including internet searches, via the Green Deal Participant Register[1], using CAR/DECC contacts, contacting organisations CAR/DECC was aware were active in the retrofit market, or recommendations from other organisations contacted during the course of the project.

As shown in Table 5, in total 52 organisations provided data, of which 49 were installers, one was an insulation manufacturer, one a trade association/society, and one a large contractor. Where participating organisations wished to be acknowledged, they are listed in Appendix B.

Table 5: Organisations contacted/involved by type

Organisation Type	Number Contacted	Number Participated
Installer	183	49
Trade Association / Society	4	1
Boiler Manufacturer	4	0
Insulation / Window Manufacturer	3	1
Procurement Organisation	3	0

[1]http://gdorb.decc.gov.uk/green-deal-participant-register, accessed February 2016.

Registered Social Landlord	3	0
Large Contractor	3	1
Total	**203**	**52**

Where organisations were able to participate, CAR gathered information through interviews or email correspondence, using a cost data template with a standard set of questions. An example is given in Figure 2 below. Companies were also asked to provide background information about their organisation (size, specialisms, main sectors served (e.g. social housing), and

Internal Wall Insulation

Total cost (materials + labour) for a specific project
No. and type of homes in project
Project location
Cost per m² wall area (materials + labour)
Cost per housetype
a. a small flat (<54m²)
b. a large flat (>54m²)
c. a small mid-terrace house (<76m²)
d. large mid-terrace house (>76m²)
e. small semi-detached or end-of-terrace (<80m²)
f. large semi-detached or end terrace (>80m²)
g. small detached house (<117m²)
h. large detached house (>117m²)
i. bungalow (around 117m²)

Is there another better way to divide up the costs - maybe with a fixed cost plus a variable cost that depends on the size of the home?
Have you done this sort of work at scale - say, on 10 or more homes together? If so, what are the costs at scale?
Are there any special considerations that would increase costs - say, electrical sockets or radiators that need to be moved, or different types of insulation? Can you quantify these?
How would you say the cost of this sort of work has changed since 2000? Can you summarise as a percentage?
And can you confirm the figures above are the whole cost, with no additional costs? Is VAT included or excluded?

significant factors affecting cost data (e.g. location)).

Figure 2: Example interview questions

CAR then collated the cost data provided by the participating organisations to provide a range of costs for each measure. The reliability of the data gathered was reviewed at this stage. Information on the impact of various factors affecting costs was included in the collated dataset (quantitative where possible, otherwise qualitative), and key assumptions were noted.

The project aimed to gather at least six costs for each measure, and we achieved this for the ten common measures, including DECC's priority measures: cavity wall insulation, solid wall insulation, loft insulation and replacement boilers. However, in some cases there were difficulties in finding sufficient data. In particular, we found issues with:

- Party cavity wall insulation: this measure is rarely undertaken, and it was difficult to identify installers who did this. However, three interviews were undertaken and two interviewees provided some cost data.
- Flat roof insulation: again, it was difficult to identify installers who did this. However, we did three interviews and two interviewees provided some cost data.
- Solid floor insulation: it was very difficult to find installers who did this, and none of those we contacted were able to provide cost data.
- Replacement glass in existing frames: most glazing installers participating in the study did not install replacement glass, and no installers provided cost data. Moreover, those that had done it advised against it and suggested it would only rarely be done, and not for entire homes.
- Secondary glazing: most glazing installers who participated in the study did not install secondary glazing, even where they were accredited to do so under the Green Deal. However, three interviews were undertaken and two interviewees provided some cost data. DIY costs were investigated separately through online searches for material or product costs.
- Hot water cylinder jackets: organisations contacted reported that this is usually a DIY measure. DIY costs were investigated separately, again through online searches for material/product costs.
- LEDs: once again, organisations contacted reported that this is usually a DIY measure, however costs were gathered from four interviewees. DIY costs were investigated separately through online searches for material/product costs.
- Draught-proofing: organisations contacted said that this is usually a DIY measure, and no professional installation costs were obtained. We also investigated DIY costs separately through online searches for material/product costs.

The cost findings for each measure are presented below. The 'low' and 'high' costs are based on the lowest and highest costs provided by the participating organisations; hence they show the range of costs provided (excluding outliers). The 'medium' costs are based on the mean values of all costs provided for each measure (excluding outliers and costs provided by organisations as 'minimum' or 'maximum' figures). Costs per house type are rounded to the nearest £100 for more expensive measures (over £1,000), and nearest £10 for measures up to £1,000.

As noted in the introduction, interviewees generally provided costs based on what they perceived to be a 'standard' or simple installation, or provided a low-high range of costs, and then commented on additional factors which would increase or decrease the costs.

Wall Insulation

Internal Wall Insulation

Ten interviewees provided cost data on internal wall insulation. A summary of their responses is provided in the table below. A summary of the feedback they provided on factors affecting costs and on changes to costs since 2000 follows the table. Generally, interviewees preferred to provide data on a per m² basis rather than on a per house type basis for this measure.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Thousands in total, though majority of interviewees appear to work at small scale and base costs on one-off installations			10
Cost per m² wall area (materials + labour)		£55	£95	£140	8 (1 of which provided minimum figures only)
Cost per house type	Small flat (<54m²)	£2,500	£2,800	£3,000	2
	Large flat (>54m²)	£3,000	£3,500	£4,000	2
	Small mid-terrace house (<76m²)	£3,000	£3,700	£5,000	3
	Large mid-terrace house (>76m²)	£4,000	£4,000	£4,000	2
	Small semi-detached or end-of-terrace (<80m²)	£5,000	£6,800	£10,400	5
	Large semi-detached or end terrace (>80m²)	£6,000	£7,000	£8,000	3
	Small detached house (<117m²)	£6,600	£7,200	£8,000	3
	Large detached house (>117m²)	£7,000	£9,400	£11,600	5
	Bungalow (around 117m²)	£5,600	£6,300	£7,000	2

Factors affecting costs:

- One interviewee suggested cost savings for installations at scale of around £5-£10/m^2, suggesting there would be some labour savings (due to working in specialist teams to undertake different tasks) and some transport savings.
- Factors cited as increasing costs included: moving or replacing fittings, moving sockets, radiators, detailing, adding ventilation, encountering damp issues, using specific products or systems (e.g. breathable products, systems in exposed areas, or systems in small rooms, where aerogel might be required which has a much higher cost – one interviewee suggested £200/m² for materials alone). Moving or replacing bathroom or kitchen fittings was also highlighted as particularly significant.

Electrical work would be more difficult in homes with older electrics, and easier in homes with modern electrics. One interviewee suggested that a ‘difficult’ install could be double the cost of an easy one, though another suggested the increase would be significant but not as much as double.

- Regional variations were also cited: one interviewee said costs are around 20% higher in the South East compared to other areas. Exposure to wind and rain, linked to location, was also highlighted by interviewees as affecting system design (to prevent damp and mould) and therefore costs.
- Several interviewees stated that the costs they provided were minimums, or excluded costs such as moving plumbing and electrics, detailing and decorating. Such exclusions are likely to have reduced the ‘medium’ figures cited in the table.

Changes in costs since 2000:

- One interviewee noted that due to the lack of approved systems in 2000 it is hard to compare costs. Another suggested that materials costs had significantly increased since 2000 due to the introduction of approved systems, but could not quantify this increase. They suggested labour costs had gone up by around 20%, though this might not all be passed on to the customer. Others did not comment or were not specific, with some references to material cost reductions or labour costs due to the company in question becoming more experienced over time. One suggested that their material costs had halved “recently” (date not given) as they moved away from an approved system.

The costs were broadly consistent with cost data from the literature review, which cited costs ranging from £6,800 to £8,900 for internal wall insulation in a semi-detached home.

External Wall Insulation

Nine interviewees provided cost data on external wall insulation. A summary of their responses is outlined in the table below. A summary of the feedback they provided on factors affecting costs and on changes to costs since 2000 follows. Generally, interviewees preferred to provide data on a per m² basis rather than on a per house type basis for this measure.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Thousands in total			9
Cost per m² wall area (materials + labour)		£55	£116	£180	6 (1 of which provided minimum cost only)
Cost per house type	Small flat (<54m²)	£4,300	£5,300	£6,100	5 (1 of which provided minimum cost only)
	Large flat (>54m²)	£6,700	£6,700	£6,700	1
	Small mid-terrace house (<76m²)	£5,500	£6,800	£8,000	5
	Large mid-terrace house (>76m²)	£7,500	£7,500	£7,500	1
	Small semi-detached or end-of-terrace (<80m²)	£7,000	£7,800	£9,000	5
	Large semi-detached or end terrace (>80m²)	£7,800	£8,400	£10,000	3 (1 of which provided maximum cost only)
	Small detached house (<117m²)	£8,900	£10,200	£12,000	5 (2 of which provided maximum costs only)
	Large detached house (>117m²)	£10,000	£11,500	£20,000	4 (1 of which provided maximum cost only, 1 minimum cost only)
	Bungalow (around 117m²)	£5,000	£9,800	£11,100	4

Factors affecting costs:

- Economies of scale: five companies suggested savings of around 5-10%, with most estimates being closer to 10%. One company quantified this as £15-20/m². Where reasons were given, the savings were attributed to labour efficiencies (e.g. allowing the team to work on other parts of a site during drying times), and to transport or preliminaries savings.
- Other factors interviewees reported as impacting on costs included: the quality or type of finish specified, moving power or telephone cables or other external fittings such as satellite dishes, extending flues, complex detailing, increased scaffolding requirements (e.g. high-rise flats), and issues such as asbestos or a need to install a new damp proof course. The finish quality was identified by several interviewees as being particularly significant. Interviewees noted the variability of costs and the need for undertaking surveys in individual homes to get a proper understanding of costs.
- Regional variations were also cited: one interviewee suggested costs are around 20% higher in the South East compared to other areas.

Changes in costs since 2000:

- Four interviewees provided information on this question. One reported little change, stating that costs had increased slightly; another gave similar feedback, suggesting a 5% increase in total; one only considered the past 4 years and suggested increases over this time of 10%; and one considered the past 10 years, suggesting 1-5% year on year increases over this time. Where reasons for cost increases were given, these were most commonly attributed to labour cost increases, though

prelims and enabling work, scaffolding costs and certification costs were also cited. One interviewee reported that materials costs have decreased since 2000.

Cavity Wall Insulation

Nine interviewees provided cost data on cavity wall insulation. A summary of their responses is provided in the table below. A summary of the feedback they provided on factors affecting costs and on changes to costs since 2000 is then provided. Generally, interviewees preferred to provide data on a per house type basis rather than on a per m² basis for this measure.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Hundreds of thousands in total			9
Cost per m² wall area (materials + labour)		£5	£6	£6	1
Cost per house type	Small flat (<54m²)	£300	£380	£630	6
	Large flat (>54m²)	£350	£430	£640	6
	Small mid-terrace house (<76m²)	£350	£460	£660	4
	Large mid-terrace house (>76m²)	£450	£505	£670	4
	Small semi-detached or end-of-terrace (<80m²)	£480	£529	£660	5
	Large semi-detached or end terrace (>80m²)	£600	£660	£690	6
	Small detached house (<117m²)	£550	£680	£800	3
	Large detached house (>117m²)	£750	£950	£1,200	6
	Bungalow (around 117m²)	£500	£650	£750	7

(Note that the m^2 cost is from a single interviewee, so should be treated with caution.)

Factors affecting costs:

- Economies of scale: seven of the interviewees responding to this question stated there would be economies of scale, relating to labour, though one said these would not be significant. Most interviewees related savings to the ability to fit in more jobs per day, with two interviewees citing a threshold of three jobs/day. One of the interviewees suggested that these economies were usually assumed in cost estimates, as this was 'normal' practice. Three interviewees quantified the savings, with one suggesting a saving of 5-10%, and two suggesting savings of 10%.
- Other factors interviewees reported as impacting on costs included: cavity size, access issues (especially conservatories, and the requirement for scaffolding), quality of work, the need to clear debris or remove existing CWI, hard to treat cavities (such as narrow cavities requiring specialist products), re-pointing, adding a damp-proof course, or ventilation. Customer service and lead generation costs were also highlighted, with one interviewee suggesting these could increase costs by 50-100%. (It is possible that this was not mentioned for other measures because high penetration rates for CWI mean that there are few easy to treat cases where owners are inclined to insulate left.)
- Product type would also affect costs. One interviewee suggested adding £100 for specialist products for narrow cavities. Several interviewees providing cost per m^2 figures gave significantly higher costs for installing beads or foam than mineral wool; though

where beads were stated as being assumed in the per house type costs this difference was not obvious.

- Regional variations were not discussed by interviewees. However, based on labour costs, it might be reasonable to assume these would be similar to those suggested for other types of wall insulation.

Changes in costs since 2000:

- Seven interviewees responded to this question. One suggested costs had fallen from about £1,000 per home in the 1990s. One suggested actual costs had not changed significantly but that prices paid due to incentives had changed and were too low in 2014-2016, whereas they were too high in 2014. Another suggested an overall increase of 25% due to admin cost increases; another said admin (not total) costs had increased by 30-40%. One suggested an overall increase (unquantified) due to material, labour and guarantee cost increases. Another suggested an unquantified increase due to material and labour. Looking at material costs only, one interviewee said that material costs had reduced by about 10% (beads) but two (beads, mineral wool) had said they had increased.

Party Cavity Wall Insulation

Only two interviewees provided cost data on party cavity wall insulation, although CAR attempted to gather more responses. This is perhaps unsurprising, as this measure is not commonly undertaken – one of the interviewees suggested that this was due to lack of funding incentives targeting this measure. A summary of the two interviewees' responses is provided in the table below. A summary of the feedback provided on factors affecting costs and on changes to costs since 2000 is then provided. One further interviewee provided some responses to other interview questions, but declined to provide cost data.

		Low	**Medium**	**High**	**No. of Interviewees (excl. outliers)**
No. of homes contributing to cost estimates		Unknown, presumed fairly low as measure uncommon.			2 (1 further interviewee participated but provided no cost data)
Cost per m² wall area (materials + labour)		£25	£28	£30	1
Cost per house type	Small flat (<54m²)	£350	£350	£350	1
	Large flat (>54m²)	£350	£350	£350	1
	Small mid-terrace house (<76m²)	£350	£350	£350	1
	Large mid-terrace house (>76m²)	£350	£350	£350	1
	Small semi-detached or end-of-terrace (<80m²)	£350	£350	£350	1
	Large semi-detached or end terrace (>80m²)	£350	£350	£350	1

Factors affecting costs:

- Economies of scale: none of the interviewees quantified these. One interviewee suggested that there would not be significant economies of scale, but it was not clear whether they had considered the question from the perspective provided by another interviewee, who stated that the numbers of installs that can be completed per day have a crucial impact on costs as the work only takes around an hour (it was suggested that 6 per day would be aimed for). This is affected by the number of homes in a project in close proximity to each other. The third interviewee suggested there would be economies but provided no detail.
- Other factors interviewees reported as impacting on costsincluded: size of wall, and size of cavity.
- Product type may also affect costs: one interviewee stated that foam and beads generally would not be used due to melting issues in walls with fireplaces. However another interviewee provided cost data for spray foam (the cost per m² figures above), which they suggested was particularly suited to hard to treat cavities. As the cost figures were provided on a different basis they are not directly comparable, though rough calculations suggest that the use of spray foam would be more expensive than mineral wool.
- Regional variations were not discussed by interviewees.However, it might be reasonable to assume these would be similar to those suggested for other types of wall insulation.

Changes in costs since 2000:

- Two interviewees responded to this question. One suggested there had been no significant changes, the other suggested there had been small increases in materials costs and increases in labour costs, but these were not quantified.

Roof Insulation

Loft Insulation (Joists)

Six interviewees provided cost data on loft insulation at joists (the usual location for insulating cold lofts), with four focussing on top-up insulation. A summary of responses is provided in the table below. We then summarise the feedback they provided on factors affecting costs and on changes to costs since 2000 is then provided. Generally, interviewees preferred to provide data on a per housebasis rather than on a per m² basis for this measure.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		10,000s in total			7(4 of which are top-ups)
Cost per m² roof area (materials + labour)		£10	£10	£20 (based on sheep's wool)	1
Cost per house type	Small flat (<54m²)	£180	£320	£580	5
	Large flat (>54m²)	£235	£430	£590	4
	Small mid-terrace house (<76m²)	£180	£350	£600	5
	Large mid-terrace house (>76m²)	£200	£420	£645	5
	Small semi-detached or end-of-terrace (<80m²)	£180	£360	£610	4
	Large semi-detached or end terrace (>80m²)	£210	£470	£650	5
	Small detached house (<117m²)	£220	£510	£750	4
	Large detached house (>117m²)	£300	£600	£955	5
	Bungalow (around 117m²)	£430	£620	£900	4

Factors affecting costs:

- Economies of scale: two interviewees suggested there is no saving from bulk installations (one of these because completing multiple jobs per day was viewed as standard), one suggested savings of 10%.
- Other factors interviewees reported as impacting on costsincluded: moving contents of loft if this is not done by DIY, virgin installations rather than top-ups (most figures were based on top-ups), providing roof ventilation, installing a loft hatch, raising and boarding joists, removing old insulation, product type, location (transport costs). Customer service and lead generation costs were also highlighted, with one interviewee suggesting these could increase costs by 50-100%.
- Regional variations were only discussed by one interviewee, who did not quantify them. They had found there to be no real variation in material costs but had found variation in labour rates, productivity (for example, due to property density and travel) and utilisation.

Changes in costs since 2000:

- Estimates of cost changes were very varied. One interviewee suggested material costs had reduced by 20% and labour from around £500 to £350 per home. Another estimated that overall costs had increased by 40%, and one that materials costs had increased by 20%. One interviewee discussed changes in the last 18 months only, suggesting that labour costs had increased by 40% and materials costs by 10% in that period. Another discussed changes in the last two and a half years only, suggesting a slight increase with material cost increases of around 6% in that period. One also noted the trend towards top-up rather than virgin loft insulation installations.

Loft Insulation (Rafters)

Five interviewees provided cost data on loft insulation at the rafters (creating a 'warm roof'), though one of these provided costs for a specific project on a home of unspecified size, and another interviewee did not provide complete cost data (interviewee data excluded). Two of them focussed on spray foam insulation, and one on PIR boards. A summary of their responses is shown in the table below. We go on to summarise the feedback they provided on factors affecting costs and on changes to costs since 2000. Generally, interviewees preferred to provide data on a per m² basis rather than per home for this measure.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Unknown. Two of the interviewees said that they had done work at scale.			4
Cost per m² roof area (materials + labour)		£20	£40	£40	3
Cost per house type	Small flat (<54m²)	-	-	-	0
	Large flat (>54m²)	-	-	-	0
	Small mid-terrace house (<76m²)	£1,300	£1,600	£2,000	2
	Large mid-terrace house (>76m²)	£1,900	£1,900	£1,900	1
	Small semi-detached or end-of-terrace (<80m²)	£1,900	£2,200	£2,500	2
	Large semi-detached or end terrace (>80m²)	£2,300	£2,300	£2,300	1
	Small detached house (<117m²)	£2,300	£2,300	£2,300	1
	Large detached house (>117m²)	£3,000	£3,100	£3,500	2
	Bungalow (around 117m²)	£2,500	£2,800	£3,000	2

Factors affecting costs:

- Economies of scale: one interviewee suggested savings of 10-20% depending on the project. Another suggested can reduce costs below minimum of £20/m² given here, based on undertaking multiple jobs per day. These figures were given by spray-foam installers.
- Other factors interviewees reported as impacting on costsincluded: what finish quality was required, ease of access, requirement to remove and reinstall plasterboard (one

interviewee suggested this could increase costs to £100/m²), remedial work, working around windows if using board, and the amount (thickness) of insulation.
- There were no significant differences between product types, based on this (small) sample.
- Regional variations were not discussed by interviewees.However, it might be reasonable to assume these would be similar to those suggested for wall insulation: around a 20% uplift for work in the South East.

Changes in costs since 2000:

- Two interviewees reported no significant changes. 1 did not quantify changes but noted impact of tightening Building Regulations.

Flat Roof Insulation

Only two interviewees provided cost data on flat roof insulation, though CAR invested additional resources in trying to identify additional interviewees. One interviewee did not state the product used, but the other used spray foam. Both provided costs per m^2 only.Another interviewee answered some of the questions, but provided no cost data.A summary of their responses is provided in the table below, followed by an outline of the feedback they provided on factors affecting costs and on changes to costs since 2000, as for previous sections.

	Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates	Unknown, low.			2
Cost per m² roof area (materials + labour)	£50	£80	£100	2

Factors affecting costs:

- Economies of scale: interviewees suggested savings would be considerable, but did not quantify these.
- Other factors interviewees reported as affecting costsincluded: access, fire break requirement, whether the work was done internally or externally, working round rooflights, the profile of existing roof, any requirement to remove existing ballast or concrete covering, or requirements for tapered insulation, and/or removing and reinstating roof fittings like aerials or satellite dishes.
- It was not possible to draw conclusions on differences between product types, due tothe very small sample and lack of information.
- Regional variations were not discussed by interviewees.

Changes in costs since 2000:

- One interviewee said there had been steady yearly increases (but they did not quantify these). However, the other had not observed any changes.

Floor Insulation

Underfloor Insulation

Only three interviewees provided useful cost data on underfloor insulation, though CAR invested extra effort in trying to identify additional interviewees. One further interviewee provided cost data for a single home of unspecified size; this was excluded. Another provided cost data based on an assumption that the floor could be insulated from a cellar, and again this was excluded from the main summary as it was not felt to represent most cases, though their answers to other questions were included. A summary of the three responses included is provided in the table below. A summary of the feedback they provided on factors affecting costs and on changes to costs since 2000 follows.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Unknown - low			3
Cost per m² floor area (materials + labour)		£1/m^2 for material, + £500-£600/floor for labour.	-	£95	2
Cost per house type	Small flat (<54m²)	-	-	-	0
	Large flat (>54m²)	-	-	-	0
	Small mid-terrace house (<76m²)	-	-	-	0
	Large mid-terrace house (>76m²)	-	£550	-	1
	Small semi-detached or end-of-terrace (<80m²)	-	-	-	0
	Large semi-detached or end terrace (>80m²)	-	£750	-	1
	Small detached house (<117m²)	-	-	-	0
	Large detached house (>117m²)	-	£900	-	1
	Bungalow (around 117m²)	-	-	-	0

Factors affecting costs:

- Economies of scale: intervieweeswho responded reported that the measure was not undertaken at scale.
- Factors interviewees reported as impacting on costsincluded: the need to replace joists and/or floorboards, electrics, access issues/ease of access (one interview cited £25/m^2 cost if they could access via a cellar). They stated that the costs would reduce if floorboards were already lifted for other renovation work. One commented that they need to know what is under floorboards to determine costs, and therefore this measure comes with a long list of terms and conditions.Some of the costs provided were based on being able to install the insulation without lifting all floorboards (i.e. by crawling into a void), others were not clear on what was assumed for this.

- Product type: there was not enough evidence to comment on relative costs of different products. Three interviewees reported costs based on mineral wool, and one on spray foam (but the latter was excluded from the main summary as an outlier, as it had been assumed that cellar access was possible).
- Regional variations were not discussed by interviewees, but a 20% uplift on costs in the South East is quite likely.

Changes in costs since 2000:

- Only two interviewees responded, one stating that costs had not significantly changed. The other commented on the last three years only, and stated that costs had not changed.

Glazing

Replacement Double Glazing (panes and frames)

Seven interviewees provided cost data on replacement double glazing. All focussed on costs for uPVC windows. A summary of their responses is provided in the table below. A summary of their feedback on factors affecting costs and on changes to costs since 2000 follows. Generally, interviewees preferred to provide costs per window or per home rather than on aper m² basis for this measure.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Unknown			7
Cost per **window** (materials + labour)		£300	£530	£1,000	2
Cost per house type	Small flat (<54m²)	£1,200	£2,400	£3,000	5
	Large flat (>54m²)	£3,000	£3,600	£4,200	4
	Small mid-terrace house (<76m²)	£3,200	£3,900	£5,000	4
	Large mid-terrace house (>76m²)	£4,800	£5,000	£5,500	4
	Small semi-detached or end-of-terrace (<80m²)	£4,800	£5,500	£7,000	4
	Large semi-detached or end terrace (>80m²)	£6,000	£6,400	£8,000	5
	Small detached house (<117m²)	£5,000	£5,900	£7,000	3
	Large detached house (>117m²)	£7,000	£8,300	£10,000	4 (1 minimum cost only)
	Bungalow (around 117m²)	£5,800	£6,600	£8,000	4

Factors affecting costs:

- Economies of scale: interviewees who responded to this question reported that they had not found significant economies of scale though it may be worth noting that interviewees were generally small-medium companies.
- Factors interviewees reported as affecting costs included the frame material, with one interviewee suggesting that aluminium framed windows would be approximately double the uPVC cost. Similarly, one interviewee suggested that timber-framed windows would also be around double uPVC costs, but another gave a figure of a minimum 50% increase over uPVC. Other factors included: window size; window style; the number of openers, dividers, splits, horizontal bars; frame colours and finishes; requirement for scaffolding (e.g. for conservatories, dormers, flats); bi-fold patio doors; distance from manufacturer; and use of triple glazing (one interviewee suggested this would increase costs by 15% over double glazing).
- Regional variations were not discussed by interviewees.

Changes in costs since 2000:

- Five interviewees responded, with three stating that costs had not significantly changed (though one noted that the energy efficiency of products had improved without increasing

costs). One suggested there had been some reductions, but did not quantify these. The other suggested that uPVC costs had significantly increased due to resin cost increases in 2009/10 and then steadily increased year on year since then, and that labour costs had increased by about 10-12% since 2000.

Replacement Double Glazing (panes only, in existing frames)

Most glazing companies participating in the study did not install double glazing panes without frames. No installers provided cost data as those that had done it advised against it and suggested it would only rarely be done, and not for entire homes. New glazed units were installed in preference, due to various factors including: changes to standard window thicknesses over time, the lack of standardisation of existing systems, benefits of installing new full units with new locks, guarantees and higher energy efficiency. One installer suggested that the costs of replacement glazing in existing frames would be around a third of the cost of installing new double glazing units, but another suggested the figure would be more like 70%.

Secondary Glazing

Most glazing installers who participated in the study did not install secondary glazing, even where they were accredited to do so under the Green Deal.New glazed units were installed in preference for performance reasons where possible. However,threeinterviews were undertaken and two interviewees provided some cost data, with the third providing costs for DIY magnetic secondary glazing. A further two interviewees who were interviewed about double glazing also commented that the overall costs are similar to those for double glazing, with one stating that materials costs are lower, but that these are balanced out by higher installation costs. A summary of the three responses included is provided in the table below. A summary of the feedback they provided on factors affecting costs and on changes to costs since 2000 follows.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Unknown			3
Cost per m² window area (materials + labour)		£110 (DIY)	£110 (DIY)	£110 (DIY)	1
Cost per house type	Small flat (<54m²)	£1,200	£1,700	£2,500	2
	Large flat (>54m²)	£5,300	£5,700	£6,000	1
	Small mid-terrace house (<76m²)	£3,500	£3,800	£4,000	1
	Large mid-terrace house (>76m²)	£5,300	£5,700	£6,000	1
	Small semi-detached or end-of-terrace (<80m²)	£1,800	£2,800	£4,000	2
	Large semi-detached or end terrace (>80m²)	£5,300	£5,700	£6,000	1
	Small detached house (<117m²)	£3,000	£4,500	£6,000	1
	Large detached house (>117m²)	£2,600	£5,900	£10,000	2
	Bungalow (around 117m²)	£3,500	£3,800	£4,000	1

Factors affecting costs:

- Economies of scale: the interviewees generally reported that they did not do this work at scale.
- Factors interviewees said affected costs included: product type, quality, style and finish; the number of openers; whether there was a colour-matching requirement with the existing frames; and fitting issues (e.g. interfaces with shutters or blinds).
- Regional variations were not discussed by interviewees, but (as for other upgrades) installation costs are likely to be higher in the South East, perhaps 20% higher.

Changes to costs since 2000:

- One interviewee reported that they had not noticed any changes; the others did not comment.

DIY costs were also investigated further through searches of the websites of companies selling secondary glazing. The findings are presented separately below. The glazing unit and slider prices are based on a window size of 1100mm x 1200 mm and exclude VAT and delivery. Prices have been rounded to the nearest pound. The magnetic secondary glazing costs are fairly consistent with the £110/m^2 cost provided by one interviewee above, with the exception of the cost from Store D, which is a product requiring self-assembly as well as fitting.

Company	Type	Product Description	Price
A	Glazing Film	Secondary Glazing Film6m^2	£7
B	Glazing Film	Secondary Glazing Film 6m^2	£7
C	Glazing Film	Secondary Glazing Film 6m^2	£9
D	Magnetic/Acrylic Secondary Glazing	Kit requiring self-assembly and fitting	1 x window = £62 5 x windows = £464 8 x windows = £765 12 x windows = £1167
E	Magnetic/Acrylic Secondary Glazing	Assembled product,for self-fitting	1 x window = £109 5 x windows = £545 8 x windows = £871 12 x windows = £1307
F	Magnetic/Acrylic Secondary Glazing	Assembled product,for self-fitting	1 x window = £121 5 x windows = £605 8 x windows = £986 12 x windows = £1452
G	Aluminium Sliders	Basic horizontal equal sliders with 4mm toughened glass	1 x window = £211

Heating

Gas Boiler Replacement

Eight interviewees provided cost data on replacement gas boilers. A summary of their responses is provided in the table below, with a summary of their comments on factors affecting costs and on changes to costs since 2000 to follow.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Unknown, thousands			8
Cost per house type	Small flat (<54m²)	£1,200	£1,700	£2,000	7
	Large flat (>54m²)	£1,300	£1,800	£2,500	5
	Small mid-terrace house (<76m²)	£1,400	£2,200	£3,000	5
	Large mid-terrace house (>76m²)	£1,600	£2,400	£3,500	4
	Small semi-detached or end-of-terrace (<80m²)	£1,600	£2,300	£4,000	4
	Large semi-detached or end terrace (>80m²)	£1,700	£2,800	£5,000	4
	Small detached house (<117m²)	£1,700	£3,200	£6,000	3
	Large detached house (>117m²)	£1,700	£4,300	£7,000	6
	Bungalow (around 117m²)	£1,700	£3,200	£6,000	3

Factors affecting costs:

- Economies of scale: most interviewees reported that they did not do this work at scale. One interviewee suggested a 10% cost saving in social housing projects at scale.
- Factors interviewees reported as impacting on costs included: system type (new and replacement, e.g. is replacement like for like), boiler make, boiler size, flue replacement, gas pipe upgrade requirement, needing to move component positions (e.g. the boiler), chemical/power flush, filter, warranty length, control types, and any requirement for a vertical flue. (See the spreadsheet linked to this report for further information.)
- Regional variations were not discussed by most interviewees. One reported that labour costs and productivity (i.e. due to transport time between jobs) would vary, whereas material costs would not, but the variation was not quantified.

Changes to costs since 2000:

- Two interviewees reported that they had not observed much change, two suggested steady increases (non-major), with a further two quantifying changes as 4-5% annual increases on boiler costs/materials. One reported an overall increase of 30% due to materials and labour cost increases.

Gas Central Heating Installation

Eight interviewees provided cost data on gas central heating installations (i.e. a boiler feeding radiators in each room and a room thermostat/timer). A summary of their responses is provided in the table below, followed by a summary of comments on factors affecting costs and on changes to costs since 2000.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Unknown			8
Cost per house type	Small flat (<54m²)	£1,900	£2,700	£3,800	5
	Large flat (>54m²)	£2,200	£3,300	£4,200	5
	Small mid-terrace house (<76m²)	£2,100	£3,400	£4,500	5
	Large mid-terrace house (>76m²)	£2,300	£3,800	£5,000	5
	Small semi-detached or end-of-terrace (<80m²)	£2,100	£3,800	£5,500	4
	Large semi-detached or end terrace (>80m²)	£2,300	£4,200	£6,000	4
	Small detached house (<117m²)	£2,300	£4,400	£6,500	4
	Large detached house (>117m²)	£2,500	£5,800	£8,000	6
	Bungalow (around 117m²)	£2,400	£4,600	£7,000	3

Factors affecting costs:

- Economies of scale: most interviewees reported that they did not do this work at scale. One interviewee suggested a 10% cost saving in social housing projects at scale.
- Factors interviewees reported as impacting on costs were similar to those for gas boilers and included: system type (new and replacement), number and size of radiators, the specification required for boiler/radiators/TRVs, needing to move radiators, pipe runlengths, flue, pipe accessibility (e.g. floor type), requirement to upgrade pipes, filter/flushes.
- Regional variations were not raised by most interviewees. One reported that labour costs and productivity (i.e. due to transport time between jobs) would vary,while material costs would not, but the variation was not quantified.

Changes to costs since 2000:

- Two interviewees reported that they had not observed much change, one suggested steady increases (non-major), and one quantified changes as 4% annual increases on materials. One reported an overall increase of 30%.

Oil Boiler Replacement

Five interviewees provided cost data on replacement oil boilers. The table below summarises responses, with comments about factors affecting costs and on changes to costs since 2000 beneath.

		Low	Medium	High	No. of Interviewees (excl. outliers)
No. of homes contributing to cost estimates		Unknown			5
Cost per house type	Small flat (<54m²)	£2,500	£2,700	£3,000	2
	Large flat (>54m²)	£2,500	£2,500	£2,500	1
	Small mid-terrace house (<76m²)	£2,500	£2,800	£3,000	2
	Large mid-terrace house (>76m²)	£2,600	£2,600	£2,600	1
	Small semi-detached or end-of-terrace (<80m²)	£2,500	£3,500	£5,000	3
	Large semi-detached or end terrace (>80m²)	£2,600	£2,800	£3,100	2
	Small detached house (<117m²)	£2,600	£3,300	£4,000	3
	Large detached house (>117m²)	£2,600	£4,300	£7,000	5
	Bungalow (around 117m²)	£2,600	£3,000	£3,500	2

Factors affecting costs:

- Economies of scale: all interviewees reported that they did not do this work at scale.
- Factors interviewees reported as impacting on costs were similar to those for gas boilers and central heating systems, with some additional factors specific to oil-based heating systems. They included: system type (for new and replacement systems), boiler make, needing to move components, the requirement to replace piping, flush, cylinder or tank replacement, tank location, long flues, oil tank pump requirement, radiator number, controls, vertical flues. (More detail is included in the spreadsheet linked with this report.)
- Regional variations were not discussed by most interviewees. One said that labour costs and productivity (i.e. due to transport time between jobs) would vary whereas material costs would not, but the variation was not quantified.

Changes to costs since 2000:

- One interviewee reported that they had not observed much change, while another suggested labour costs remained similar but that VAT costs had increased. Another suggested an overall increase of around £1,000 due to overhead, boiler and admin cost increases. Finally, one suggested materials had increased by 4% on average, year on year.

Hot Water Cylinder Insulation (Jacket)

Only one interviewee was identified who installedhot water cylinder jackets professionally, despite attempts to find more interviewees. They suggested a cost of £10-£20 per jacket depending on size, plus £70 for labour (based on 1 hour). However, they noted that installing jackets professionally would only be feasible if the property was close to the company's location. They reported that factors affecting costs would include the need to insulate cylinder pipework and transport/parking costs in London.

Because of the lack of interviewees involved in professional installations, we also sought DIY costs through internet searches of company websites. The costs found are shown in the table below.

Company	Price
A	£15
B	£15
C	£15
D	Armadillo £37-£41 / Sheepwool £70
E	£10

Heating Controls

Separate costs were sought through internet searches of company websites for some different control types (product costs only, excluding fitting). These are shown in the table below.

Company	TRVs	Room Thermostats	Timers and Controls
A	£7 - £40	£10 - £70	£20- £143
B	£7 - £29	£16 - £56	£36 - £75
C	£14	-	-
D	£10 - £43	£13 - £75	£49 - £123

LEDs

Four interviewees provided cost data on LEDs. One provided costs for fittings, two provided costs for bulbs only (of the latter, one interviewee's costs were based on a sample of 23 domestic LED models, with similar models from different manufacturers excluded: this interviewee provided figures showing the range of costs and average cost). The fourth provided costs per home. A summary of their responses is provided in the table below, with factors affecting costs, and changes to costs since 2000,to follow.

	Low	**Medium**	**High**	**No. of Interviewees (excl. outliers)**
No. of homes contributing to cost estimates	Unknown			4
Cost per bulb (DIY)	£2.00	£7.50	£20.40	2
Cost per fitting (installed)	£50	£50	£50	1
Cost per small semi-detached or end-of-terrace (<80m²)	£200 **bulbs only**	£250 **bulbs only**	£300 **bulbs only**	1

Factors affecting costs:

- The model of bulbs used, with B22 and E27 bulbs a little more expensive than GU10s, MR16s or E14s.
- Economies of scale: all interviewees reported that they did not do this work at scale, but one noted that there are economies of scale within individual homes.
- Factors interviewees reported as influencing costs included: providing extra fittings or switches, and requirements for wiring alterations, drivers, and transformers.
- Regional variations were not discussed by interviewees.

Changes to costs since 2000:

- Three interviewees responded, all commenting that bulb prices have reduced. One of the three quantified this as a 30% decrease.

DIY costs for LED bulbs only were also sought through internet searches of company websites. The costs found are shown in the table below.

Company	Bulb Type				
	GU10 (5W)	MR16 (5W)	B22	E27	E14
A	£6	£8	£6 (3 for £10) (6W)	£6 (3 for £10) (6W)	£7 (6W)
B	£5 - £7	£7	£7 (6W)	£7 (6W)	£8 (5W)
C	£3.50	-	£8 (4W) / £9 (8.2W)	£9 (5W)	£6.50 (2.5W)
D	£6	£5 - £7	£6 (5W)	£5 - £10 (5W)	£5 (5W)

Draught-proofing

We were unable to identify any interviewees who installed draught-proofing professionally. (This is not surprising, as this tends to be a DIY measure.) Again, DIY costs for draught-proofing were sought through internet searches of company websites. The costs found are shown in the table below.

Company	Window film (6m²)	Seal for doors and windows	Letterbox draught excluder	Door brush draught excluder	Chimney draught excluder
A	£8	£4 for 6m	£19	-	£13.50 - £47.50
B	£9	£4.50 for 5m £8 for 10m	£7.50 - £20	£8	-
C	£7	£6.50 - £7 for 10m	£5 - £13	£5	-
D	£7	£7 for 10m £11 for 20m	£5 - £20	£13	£17 - £66

Conclusions

This project provides very useful information about the costs of retrofitting homes and about the factors which can affect costs. It is not a definitive study, because resources were limited, but it offers robust *indicative* costs for the most important common upgrade measures: cavity and solid wall insulation, loft insulation, and energy-efficient replacement boilers.

Differences between individual dwellings and specific circumstances (access, materials, space limitations, or even planning restrictions) affecting each installation mean that it is impossible to give an accurate cost estimate for installing most of these upgrades without carrying out a full survey first. The quality or type of finish specified, moving power or telephone cables or other external fittings such as satellite dishes, extending flues, complex detailing, increased scaffolding requirements all also affect costs, and tend to make work more expensive. Further, special considerations such as having asbestos or a need to install a new damp proof course also bring additional costs that are impossible to quantify in a short study.

Regional variations are also important, cited by many interviewees in relation to wall insulation, and one interviewee said that this form of insulation is around 20% more expensive in the South East than other parts of the UK. This is mainly due to higher labour costs in the South East.

The cost data gathered from interviews was generally fairly consistent to the data found in the literature review, with some exceptions (like under floor insulation, where the literature quoted much higher costs). However, modest sample sizes per measure (in particular for less common measures) means that additional work and more interviews would strengthen the evidence base.

A further limitation of this study stems from possible differences between the precise specifications of different upgrade measures (in materials, insulation thicknesses, and methods of application). There may also be some differences between what different interviewees included or excluded in the costs they gave. Several interviewees also made the point that they were giving costs for *straightforward* installations (with easy access, no need for complex scaffolding, and no asbestos or special circumstances that would almost certainly increase the costs they cited).

Longer term, it would be unwise to assume these costs are fixed over time. Indeed, most interviewees recognised that the cost of most upgrades has increased since 2000, with different changes affecting different measures. External factors, including Government policy and particularly grants and financial incentives for carrying out upgrades are a major factor shaping both the common specifications for work, and the size of the market – both of which contribute to determining costs.

For example, financial support schemes like the Green Deal and the Energy Company Obligation have the effect of dictating how upgrades are implemented and (in the past, at least) tend to set the bar for how to carry out energy efficiency improvements, as well as driving area-wide upgrade schemes. This means that future energy policies could have a decisive effect on not just the volume of energy efficiency upgrades (the number of homes improved) but also

their specification, which inevitably affects their cost. This is especially true for (internal and external) solid wall insulation, where complex detailing around junctions brings thermal improvements but also makes installation costs considerably more expensive.

There is also evidence that costs will continue to rise, mirroring gradual increases in labour costs (and, in some cases, materials costs, which have reportedly risen for some measures).

The cost of generating leads was mentioned in relation to cavity wall insulation and loft insulation. This may be evidence that the market for these measures is becoming saturated, which has implications for the continued viability of insulation firms concentrating on these measures.

This study has focused only on installed costs of upgrades, without assessing the potential energy, carbon and cost savings that might accrue from carrying out these upgrades. This would be critical for investment decisions (either at the micro/householder scale, or at the macro-government scale), where installed costs must be weighed against the potential savings. In the same vein, we found relatively minor cost reductions for installations at scale (5-20%), which may argue against street-level or area-wide improvement schemes.

Similarly, this study has not attempted to assess full lifecycle costs of upgrade measures (recognising that some upgrades, like boilers or draught-stripping, might last 10 or 15 years, and then need replacing, whereas wall or loft insulation might last much longer).

Recommendations for future work

We think that future work could build upon the data presented here and in the associated spreadsheet, by increasing the sample sizes for interviews – particularly for less common measures where we were unable to find more than one or two interviewees. It would also be valuable to apply a pre-defined set of specifications for each measure, which would give greater consistency between the cost figures presented.

We also see value in spending more time investigating the factors which interviewees identified as affecting costs, and focusing in particular on regional cost variations, which were rather inconclusive for most measures in this study – apart from limited evidence that labour costs are 20% higher in south-east England.

Appendix A: Literature Review Supporting Tables

CAR Summary of Literature Review Findings

Source	Focus / Measure Studied	Findings – Costs per m^2 element area or per house type	Key Cost-related Findings – Other	Reliability Rating
Affinity Sutton, *FutureFit Final Report Part One*, 2011; *FutureFit Installation phase in-depth findings*, 2011; *FutureFit Financial modelling in-depth findings*, 2012.	**CWI**	£15.10/m^2 Based on houses only; costs for flats expected to be higher due to access issues.	Based on monitored costs from retrofitting packages of measures to 102 homes in various locations across England. FutureFit installed costs were generally higher than EST Housing Model costs, but were lower for boilers (EST Housing Model figures do notinclude VAT, preliminary costsand overheads. FutureFit costs do include these factors, but were adjusted to allow a comparison. FutureFit costs include	High – though note report date of 2011 and sample sizes per measure not always clear.
	Loft insulation (top-up)	£64 fixed[3] + £6.70/m^2		
	IWI	£2,356 + £72.80/m^2		
	EWI	Not done. Estimate was £310 + £156/m^2 excluding VAT, prelims and overheads. Includes costs for taking		

[3] Fixed costs are costs which are relatively constant between house types (for example, they might include labour costs). Additional variable costs are generally given per square metre, and depend on the element area.

Source	Focus / Measure Studied	Findings – Costs per m^2 element area or per house type	Key Cost-related Findings – Other	Reliability Rating
		insulation down to top of foundation footing detail, adapting below ground drainage provision and planning.	contractor profit).[2] Several reasons were identified for this variation including: FutureFit using a higher specification, thinner floorinsulation (aerogel overlay insulation) to avoid consequential works on stair risers and doors, supply chain issues. However, the cost of mature measures, such as cavity and loft insulation, was (2-3 times) higher. FutureFit costs exclude engagement and survey costs. From survey to completion, the number of visits per property ranged	
	Floor insulation (overlay)	£2,814 + £77.30/m^2 + additional £26.50m^2 where floor covering needs replacement.		
	Floor insulation (suspended timber)	£2,814 + £61.20/m^2 + additional £26.50m^2 where floor covering needs replacement.		
	Floor insulation (suspended timber, existing exposed boards)	£833 + £59.20/m^2		

[2] EST Housing Model cost documentation was no longer available on the EST's website but the data comparison is given in the Future Fit reports, and included in the supporting tables below.

Source	Focus / Measure Studied	Findings – Costs per m^2 element area or per house type	Key Cost-related Findings – Other	Reliability Rating
	DHW cylinder insulation jacket	£39.50/jacket	from 6 to 20. Additional estimated cost of engagement (including phone calls, letters, emails and visits) was approximately £450-£1,350 per property. Installation issues affected costs of measures, in particular IWI (e.g. moving kitchen and bathroom fittings on/abutting external walls, skirtings, window beading, architraves, internal doors abutting external walls, moving pipework, electrical and telecommunications equipment etc.) and overlay floor insulation (combinations of floor types in homes, appliances installed under worktops meaning worktops, wall units and tiling needed repositioning, need to create level thresholds, need to install new floor covering where existing one glued down), giving high fixed costs. These costs may not be reflected in other estimates depending on the specification followed. CWI costs were affected by issues associated with the poor quality of existing fill where this was in place.	
	Double glazing	£585/window		
	Draught proofing	Not done except on one door: £65/door. Estimate was £45/window excluding VAT, prelims and overheads.		
	LEDs	£4.20/bulb		
	Heating controls	£41/TRV		

Source	Focus / Measure Studied	Findings – Costs per m^2 element area or per house type	Key Cost-related Findings – Other	Reliability Rating
			Cost ranges for some measures e.g. IWI were wide, whereas for others e.g. heating controls there was little variation. Window costs varied depending on type (sash, opened/sealed etc.)	

Element Energy and Energy Saving Trust, *Review of potential for carbon savings from residential energy* efficiency, 2013	Update of evidence base on technical potential for installation of domestic energy efficiency measures (last updated by CCC in 2011). Cost data from various reports, surveys etc. analysed by EST to inform MACC assessment.	Note costs for all the measures are based on price charged by installer so include VAT, materials, labour, search / lead / marketing costs. Exclude Green Deal Advice Report and Technical Surveys required for GD/ECO and search / lead costs for certain elements of ECO where eligibility is restricted. Exclude grants, subsidies, hidden and hassle costs. Low / Med / High costs are given (med costs are included below). Three property types: 'small' (flats), 'med' (bungalows and terraces), 'large' (semi-detached and detached).		High – though some issues with SWI costs expressed by INCA, and some data samples very small so lower confidence in data for some measures (e.g. floor insulation). Also note report date is 2013.

		Dimensions based on BRE document.[4]		
	EWI	Fixed cost £6000 + variable cost of £111.49/m^2 wall area. Gives a total cost of £15,120 for a large semi (81.9m^2 external wall area).	Costs based on Purple Market Research, *Solid Wall Insulation Supply Chain Review*, Energy Saving Trust, Energy Efficiency Partnership for Homes, 2009 with VAT added. Not clear if/how costs updated to 2013 costs.	
	IWI	Fixed cost £2400 + variable £73.35/m^2 wall area.		
	CWI – Easy to treat	Fixed cost £250.12 + variable £5.06/m^2 wall area.	Costs based on National Insulation Association survey of its members.	
	CWI – Hard to treat	Fixed cost £2240.42 + variable £4.76/m^2 wall area. (Average for different wall types; figures by wall type are provided separately).	Solutions for different wall types based on studies by BRE and Inbuilt Ltd/Davis Langdon for DECC (*A study of Hard to Treat Homes using the English Housing Survey Part 1*, 2008; *Study on hard to fill cavity walls in domestic dwellings in Great Britain*, 2010;	

[4] ILES. P, J, *Standard Dwellings For Energy Modelling*, Centre for Technology Statistics and Assessment, Department of the Environment Transport and the Regions, 1999.

			Review of the number of cavity walls in Great Britain, 2012). Costs based on the latter 2 reports, Spon's *Architects and Builders Price Book* 2013 and Calderdale Council *Hard to Treat or Hard to Fund? Final Report Retrofit Insulation Pilot Project*, 2011.	
	Loft insulation	Fixed cost £157.97 + variable £0.012/(mm insulation thickness*m^2 loft area). 'Hard to treat': Fixed cost £986.82 + variable £22.79/m^2 loft area.	Mainly based on a survey of National Insulation Association members.	
	Solid floor insulation	£29.27/m^2 ground floor area	EST Pay As You Save (PAYS) pilot scheme. Very small sample: 13 homes.	
	Suspended timber floor insulation	£8.81/m^2 ground floor area		
	Double glazing	Fixed cost £1683.62 + variable £108.65/m^2 window area.	Mainly based on Glazing Federation data, sample of 7 homes only.	
	Draught proofing	£3.57/m window and door perimeter	Based on National Insulation Association quote.	

	Condensing boiler	£2401.52 (per dwelling)	Based on 2010 boiler scrappage scheme data (sample of several thousand).	
	Heating controls (timer, thermostat, TRVs)	£451.71 (per dwelling)	Based on online search of major retailers (B&Q, Screwfix, Wicks). Install costs from Spon's*Electrical and Mechanical Price Book* 2013 (assume 1.15 hours at same rate as for boiler installation).	
	Hot water tank insulation	£12.65 (per unit)	Source not given.	
	LED lamps	£9.80/bulb	Source not given.	

EST website, 'Home Insulation' pages, accessed Mar 2016[5]	Provides professional installation costs for a range of measures.			Medium – not clear when installation cost figures were last reviewed. Source for costs not clear, though understood to be based on discussions with trade associations, manufacturers and installers.[6]
	Loft insulation (virgin)	Detached: £395 Semi: £300 Mid-terrace: £285 Bungalow: £375	Based on U-value of 0.16W/m^2K	
	Loft insulation (top-up)	Detached: £290 Semi: £240 Mid-terrace: £230 Bungalow: £280	Based on 120mm to 270mm, U-value of 0.16W/m^2K	
	CWI	Detached: £720 Semi: £475 Mid-terrace: £370 Bungalow: £430 Flat: £330	Based on U-value of 0.5W/m^2K. Based on standard cavity walls.	
	IWI	Flat: £4,000	Based on U-value of 0.3W/m^2K. Notes that costs vary significantly depending	

[5] http://www.energysavingtrust.org.uk/domestic/home-insulation (Accessed March 2016)

[6] Based on commentary in WWF, *Mind the Gap: Funding Home Energy Efficiency to Deliver Scotland's Climate Change and Fuel Poverty Targets,* 2012

		Detached: £13,000 Cost for semi, terrace, bungalow in between above range.	on level of work required.	
	EWI	Flat: £8,000 Detached: £22,000 Cost for semi, terrace, bungalow in between above range.	Based on U-value of 0.3W/m^2K. Notes that costs vary significantly depending on level of work required.	
	Draught-proofing	£85 - £275	Based on DIY, materials costs only.	
	Hot water tank insulation jacket	£15	DIY cost.	
EST for DECC, *Non-standard CWI costs* Excel spreadsheet, provided Feb 2016.	EST provided data on **non-standard CWI** costs from a project being undertaken separately for DECC. The data was based on interviews with installers who were asked for material, labour and total costs (it is assumed VAT is included though this may not have been explicitly stated). These are included in the supporting tables in Appendix A.			High
INCA, *Committee on Climate Change – Solid Wall Insulation Review*, 2015	**SWI** The report provides evidence to CCC on SWI in response to a call for evidence.	Blended average cost (all installation scales): £7,140, based on an average net external wall area of 80m^2. 25% lower cost for 'under 100 home'	- Approx. 75% of SWI is EWI, based on 'An analysis of the market for external wall insulation', BDS Marketing Research, 2013. - This figure is >90% for government-funded schemes, based on The Final Report of the Community Energy Savings Programme (CESP) 2009 – 2012 and Domestic Green Deal, Energy Company Obligation and Insulation Levels in Great Britain,	High

		install projects vs single home, and 30% lower cost for 'over 100 home' projects vs single home (detailed costs given separately below). Not clear if these costs are based on EWI or IWI. Probably EWI as they are compared to other EWI costs and the report notes EWI accounts for most SWI installations. These costs are compared to CCC proposed figures for SWI which are based on the Element Energy/EST 2013 report. Assume VAT and lead/marketing costs	Quarterly Report, December 2014. - Suggests main cost variable is house type and resulting wall area. - Install costs not related to tenure - But marketing costs are lower for social housing than private housing (but similarly low on private housing area-based schemes). Marketing costs are very dependent on policy (per customer costs given are £20 under CESP, £50-250 under ECO, £300-500 under Green Deal). - Admin and monitoring costs vary based on policy rather than measure/tenure. These are fixed costs. - Roll-out scale and geographical location should be considered together (as urban areas likely to be larger scale, rural more likely to be single homes) - Install costs not directly related to solid wall type (i.e. concrete, brick, stone) but install solution is dependent on type (e.g. IWI mostly on stone, hybrid IWI/EWI on exposed brick and EWI on concrete and pre-rendered brick/stone). - The influence of policy on costs is noted, for example policy can reduce costs through promoting area-based, multi-measure interventions linked to trigger points, through allowing steady growth and stability in the market via long-term funding, and through other	

		are included as costs are compared directly to CCC ones which include these factors.	means of promoting/mainstreaming energy efficiency upgrades e.g. consequential improvement type policies. In a follow-up discussion with one of the report authors it was also noted that the quality/technical standards (e.g. approach to detailing, proportion of wall area to be insulated) set for different measures also has a significant impact on costs. - Innovations in product and installation methods and learning would also reduce costs. - It was suggested that cost reduction (excluding policy impacts and changes to scale) could possibly be quantified and projected by comparing 2007 to current costs (as changes would have occurred with little scale change and without a secure policy environment); however it is suggested that this approach would need more consideration.	
Retrofit contractor, personal communication, Feb 2016 (figures based on a study in 2015)	Provides estimated costs for various measures. These are indicative averages; actual costs would vary depending on house size, extra work issues etc.		Notes the need for national minimum quality standards and monitoring – this will affect costs.	Medium – not clear where costs are from. CWI / loft insulation and room in roof / floor insulation costs not differentiated.
	Boiler replacement	Flat: £1,500		

	(inc. heating controls)	2-3 bed semi: £1,600		
	CWI or **loft insulation**	Flat: £400 2-3 bed semi: £600		
	SWI	£2000 + £75/m^2		
	Room in roof or **floor insulation**	£1000 + £60/m^2		
Sweett Group, *Retrofit for the Future: analysis of cost data for the Technology Strategy Board Final Report*, 2014	Analysis of cost data from the TSB Retrofit for the Future programme which involved over 100 homes across the UK and a range of retrofit measures. Data outliers were identified and removed where they could be explained. Average (and min-max range) 'supplied and fitted' costs are shown below, excluding outliers. Graphs showing all data points are given in	Costs are provided on a per m^2 basis.	Provides recommendations on how cost data should be recorded and reduced, and a template for structuring cost data for future retrofit projects. Identifies significant factors affecting costs: use of non-standard/bespoke products, sourcing products from far away/with immature supply chain, final finish/product specification, poorly designed/installed products/systems requiring remedial work. Detail is provided in the report along with advice on how to avoid issues, and reduce and manage costs.	High – though note the programme ran from 2009 so some of the cost data is potentially pre-2010.

	the report.			
	Double glazing	£261/m^2 (£150/m^2 - £413/m^2)	Based on 10 installations. Based on 'high-performance' units, some with U-values of 1.1 W/m^2K.	
	Triple glazing	£567/m^2 (£223/m^2 - £1,022/m^2)	Based on 21 installations. Non-standard sizes or having large variation in sizes increased costs, as well as other factors identified above.	
	IWI – rigid (EPS / XPS / PUR / PIR)	£123/m^2 (£56/m^2 - £177/m^2)	Based on 4 installations. For all IWI insulation types, where temporary rehousing of residents was required (not usual) this added c.£3000-5000 to costs. Requirements for repositioning of sockets, skirting, coving, wall furniture affected labour costs.	
	IWI – natural boards (timber fibre / sheep's wool)	£368/m^2 (£134/m^2 - £602/m^2)	Based on 2 installations.	
	IWI – 'hi tech' (aerogels or Vacuum Insulated Panels)	£359/m^2 (£128/m^2 - £663/m^2)	Based on 5 installations.	
	EWI – rigid	£161/m^2 (£63/m^2 - £288/m^2)	Based on 12 installations. For all EWI insulation types, specifying complex cladding types increased costs. Report notes that EWI installers indicated that costs may have decreased since as	

			installer experience is increasing.	
	EWI – natural boards	£150/m^2 (£143/m^2 - £156/m^2)	Based on 2 installations.	
	Floor insulation – rigid	£65/m^2 (£12/m^2 - £131/m^2)	Based on 9 installations. For all floor insulation types, suspended timber floors were cheaper to insulate than solid concrete floors which had to be overlaid with expensive hi-tech insulation materials or concrete had to be broken up and reinstalled with rigid insulation below the screed.	
	Floor insulation – natural boards	£94/m^2	Based on 1 installation.	
	Floor insulation – 'hi tech'	£130/m^2 (£54/m^2 - £272/m^2)	Based on 7 installations. Materials required careful handling or products such as VIPs could be damaged, compromising performance and incurring replacement costs. One project used foam-fill beneath the timber floor to avoid lifting floorboards but this approach ultimately did not save time due to time required to identify wiring locations.	
	Roof insulation – rigid	£82/m^2 (£39/m^2 - £133/m^2)	Based on 5 installations. For all insulations types, whether there was a room in the roof affected costs –	

			requiring finishing and potential more expensive materials to fit behind boarding. Installations all went beyond Building Regulations requirements in terms of U-values, avoiding future top-up costs.	
	Roof insulation – natural boards	£30/m^2 (£XX/m^2 - £57/m^2) – incorrect minimum figure given in report, appears from graphs that correct figure is around £4/m^2 though this seems very low.	Based on 2 installations.	
	Roof insulation – loose fill (mineral fibre quilt / cellulose fibre)	£14/m^2 (£6/m^2 - £30/m^2)	Based on 6 installations.	
Which? website, 'Creating an energy saving home' pages, accessed Mar 2016[7]	Provides costs for a range of measures. Loft and wall insulation costs are based on EST figures above, though EWI and IWI cost ranges are different from those on EST website (Which? Gives £5,000 - £18,000 for EWI; £3,000 - £14,000 for IWI)			Medium – not clear when cost data last updated, or source for costs.
	Floor insulation – suspended timber	DIY: £100 Professional: £300-	Not differentiated by house type.	

[7]http://www.which.co.uk/energy/creating-an-energy-saving-home (Accessed March 2016)

	floor	£750		
	Floor insulation – solid floor	Professional: £950-£2,200	Not differentiated by house type.	
	Draught-proofing	DIY: £120 - £290 Professional: £200 – £580	Not differentiated by house type.	
WWF, *Mind the Gap: Funding Home Energy Efficiency to Deliver Scotland's Climate Change and Fuel Poverty Targets,* 2012	Compares EST and DEMSCOT costs for various measures – see supporting table below. However, the EST costs are different from those presented on the EST's website (at March 2016) so are presumably outdated.			L/M - costs cited assumed to be outdated.
Citizens Advice Bureau, *Raising standards, cutting bills*, 2014	No cost data relating to individual measures.			-
GLA, *RE:NEW Roll-out Evaluation Report – 2011/12*, 2013	No cost data relating to individual measures.			
GLA, *Domestic Retrofit 2015*, 2015	No cost data relating to individual measures.			-
IPPR, *Help to Heat: A Solution to the*	No cost data relating to individual measures.			-

Affordability Crisis in Energy, 2013		
RICS, *The Greener Homes Price Guide*, 2008	Includes costings for various measures for a variety of house types and specifications. Includes CWI, EWI, IWI, loft insulation, floor insulation, window replacement, boiler replacement, and hot water cylinder jacket. Also includes location adjustment factors	Cost data prior to 2010, so excluded here.
Verco and Cambridge Econometrics, *The economic and fiscal impacts of making homes energy efficient*, 2014	No cost data relating to individual measures.	-

Affinity Sutton, FutureFit Installation phase in-depth findings, 2011

Average Costs of Measures Compared to Estimates and to EST Housing Model 2010 Costs

	EST Housing Model			Pre-works estimated costs (excl. prelims, overheads and VAT)				Average incurred costs across all archetypes (excl. prelims, overheads and VAT)			Total cost incl. prelims, overheads and VAT	
	Cost			Cost				Cost			Cost	
Measure	Fixed	Marginal	Unit	Fixed	Marginal	Unit	Notes	Fixed	Marginal	Notes	Fixed	Marginal
Cavity Wall Insulation		£4.75	£/m²		£12 - £18	£/m²	Costs dependant on no. of storeys		£11.75	Measure not installed in block of flats where cost expected to be higher due to access issues		£15.1
Loft Insulation	£240	£0.018	£/mm. m²	£50	£7.0	£/m²	400mm Rockwool insulation					
Loft Insulation (Top-up)	£240	£0.018	£/mm. m²	£50	£5.5	£/m²	200mm Rockwool insulation	£50	£5.20	Cost range £4 - £9.8	£64	£6.7
Internal Wall Insulation		£70	£/m²	£1,420	£64	£/m²	Fixed costs relate to - relocating resident's belonging - removing and refitting kitchen and bathroom fittings - removing existing tiling in kitchen/ bathroom - Removing and re-fixing window beading and door architraves, plus supply of new window boards.	£1,832	£57	Marginal cost range £45 - £106. Higher end of the range for one specific property due to the small area to be treated. This value has been excluded when calculating the average marginal cost for the measure.	£2,356	£72.8
External Insulation	£1,500	£85	£m²	£310	£156	£/m²	Marginal costs include costs for excavation to ensure that external insulation is taken down to the top of the foundation footing detail.			Measure not installed due to planning issues		

	EST Housing Model			Pre-works estimated costs (excl. prelims, overheads and VAT)				Average incurred costs across all archetypes (excl. prelims, overheads and VAT)			Total cost incl. prelims, overheads and VAT	
	Cost			Cost				Cost			Cost	
Measure	Fixed	Marginal	Unit	Fixed	Marginal	Unit	Notes	Fixed	Marginal	Notes	Fixed	Marginal
							Fixed costs relate to - adapting below ground drainage connections - planning permission					
Floor Insulation		£42.52	£/m²	£2050-£1640	£45	£/m²	**Insulation to floor – Overlay** Marginal costs relate to aerogel insulation bonded to chipboard. Fixed costs relate to - Removing and re-fixing kitchen fittings - Removing and re-fixing bathroom fittings - Removing and re-fixing floor coverings - Removing and re-fixing skirting boards - Storage of residents belongings Range dependant on whether resident belongings stored within property or off-site container	£2,188	£60.10	Marginal cost range £38 - £73 across the three contractors. This cost does not include floor covering replacement at an additional cost of £26.5/m2 (5 of the 6 properties that had floor insulation installed had floor covering replaced). Instead the avg. cost for removing and re-fixing floor coverings has been added to the fixed costs. Storage containers provided to avoid the need for decanting at an additional cost of £350 per property.	£2,814	£77.3

	EST Housing Model			Pre-works estimated costs (excl. prelims, overheads and VAT)				Average incurred costs across all archetypes (excl. prelims, overheads and VAT)			Total cost incl. prelims, overheads and VAT	
	Cost			Cost				Cost			Cost	
Measure	Fixed	Marginal	Unit	Fixed	Marginal	Unit	Notes	Fixed	Marginal	Notes	Fixed	Marginal
				£2050-£1640	£56	£/m²	**Insulation to Suspended Timber floor - Existing covering provided over boards** Fixed costs as above	£2,188	£48	Marginal cost does not include floor covering replacement at an additional cost of £26.5/m². Instead the avg. cost for removing and re-fixing floor coverings has been added to the fixed costs.	£2,814	£61.2
				£1250-£840	£52	£/m²	**Insulation to Suspended Timber floor - Existing exposed boards** Fixed costs relate to - Removing and re-fixing skirting boards - Storage of residents belongings Range dependant on whether resident belongings stored within property or off-site container	£648	£46		£833	£59.2
Insulated doors		£500	£/door		£900-£1200	£/door	External door/ Front entrance door		£800-£832	Average of external door/ front entrance door		£1,175 - £1,223
Foam insulated DHW cylinder		£400	item		£850	item	Includes cost of new 50mm factory insulated cylinder; includes insulating all existing primary pipework		£706	Cost range £500 -£775		£1,038

	EST Housing Model			Pre-works estimated costs (excl. prelims, overheads and VAT)				Average incurred costs across all archetypes (excl. prelims, overheads and VAT)			Total cost incl. prelims, overheads and VAT	
	Cost			Cost				Cost			Cost	
Measure	Fixed	Marginal	Unit	Fixed	Marginal	Unit	Notes	Fixed	Marginal	Notes	Fixed	Marginal
Primary Pipework insulation		£101	item									
Insulation jacket					£40	item			£31			£39.5
Double glazing		£200	£/m²		£478	per window	Plus associated works to reveals; U-value of 1.6W/m2K (compared to 1.8W/m2K for the EST spec)		£398	Cost range £245 - £448		£585
Reduced infiltration A - to 5m³/m².h		£240	item		£630	item	For airtightness Pkg 1 - 'complete air tightness improvement works' to Archetype 3; Predicted costs vary with archetype (from £440 - £1040) depending on property size, number of windows and doors, etc. Costs shown for Archetype 3.		£656	This package was carried out for Archetype 3 only with improvement in airtightness from average of 10.3 m³/m²/h @50Pa pre-works to 9.2 post-works		£964
Reduced infiltration B - to 1m³/m².h (incl. Heat Recovery)	£3,500		item		£3,580	item	No comparable specification. Cost for airtightness package 1 above and whole house mechanical ventilation.		£2,315	No comparable specification. Cost for airtightness package 1 above and whole house mechanical ventilation.		£3,402
Draught proofing	£101		item	£70	£45	per window	Fixed cost of £70 is cost of draughtproofing door	£65	–	No data available for windows. Data for doors relates to one property only.		–
Heat Recovery	£3,500		item	£2,950			MVHR System	£2950		Cost range £740 - £2950. Lower end relates to specific	£4,336	

	EST Housing Model			Pre-works estimated costs (excl. prelims, overheads and VAT)				Average incurred costs across all archetypes (excl. prelims, overheads and VAT)			Total cost incl. prelims, overheads and VAT	
	Cost			Cost				Cost			Cost	
Measure	Fixed	Marginal	Unit	Fixed	Marginal	Unit	Notes	Fixed	Marginal	Notes	Fixed	Marginal
										properties which already had mechanical extract systems installed and therefore required no new ducting.		
Low energy light bulbs		£2.50	£/bulb		£3	£/bulb			£2.8			£4.2
Heating controls	£398.4		per dwlg.		£28	per TRV			£32			£41
					£450	zoned heating control	3-zone systems with motorised values		£608	Average costs for three different specifications used on site – original specification (~£630), Honeywell 2-zone wireless systems (~£975) and programmable TRVs with time and temperature control (£415).		£782
					£130	weather compen sator			£134			£173
					£100	boiler interlock			–	Not installed		–

	EST Housing Model			Pre-works estimated costs (excl. prelims, overheads and VAT)				Average incurred costs across all archetypes (excl. prelims, overheads and VAT)			Total cost incl. prelims, overheads and VAT	
	Cost			Cost				Cost			Cost	
Measure	Fixed	Marginal	Unit	Fixed	Marginal	Unit	Notes	Fixed	Marginal	Notes	Fixed	Marginal
Condensing boiler replacement (gas)		£2,500	item		£1,037		Excludes cost for new insulated cylinder		£1,398	Cost range £1,298 - £1455		£2,055
Low flow water fittings		£25	per tap		£40	per tap			£40			£59
		£55	per shower		£55	per shower			£51			£74
Photovoltaic panels	£2,000	£4,300	£/kWp	£300	£4,500	£/kWp	Fixed costs relate to BWIC	£351	£6,200	Cost range £3,160 - £10,111 depending on installed system size.		£9,112

Element Energy and Energy Saving Trust, Review of potential for carbon savings from residential energy efficiency, 2013

Low/Med/High Costs for Various Measures; Hard to treat cavity wall costs by wall type

Measure	Fixed costs	Variable cost	Low Fixed Cost	Low Variable Cost	High Fixed Cost	High Variable Cost	Variable cost unit	Variable
External wall insulation	£6,000.00	£111.49	£3,600.00	£111.49	£8,400.00	£111.49	m2	Wall Area
Internal wall insulation	£2,400.00	£73.35	£1,200.00	£66.01	£3,600.00	£80.68	m2	Wall Area
Easy to treat cavities	£250.12	£5.06	£236.95	£4.04	£263.28	£5.15	m2	Wall Area
Hard to treat cavities (CWI Solution)	£2,240.42	£4.76	£1,293.31	£3.80	£2,875.70	£4.84	m2	Wall Area
Limited savings easy to treat cavities	£250.12	£5.06	£236.95	£4.04	£263.28	£5.15	m2	Wall Area
Loft Insulation	£157.97	£0.012	£144.805	£0.011	£171.134	£0.013	mm x m2	Thickness required * Loft Area
Hard to treat lofts	£986.82	£22.79	£564.06	£13.03	£1,763.46	£40.73	m2	Loft area
Solid floor insulation	£0.00	£29.27	£0.00	£24.85	£0.00	£46.22	m2	Ground Floor Area
Suspended timber floor insulation	£0.00	£8.81	£0.00	£2.18	£0.00	£13.26	m2	Ground Floor Area

B-rated double glazing	£1,683.62	£108.65	£1,482.16	£95.65	£1,885.07	£121.65	m2	Window Area
Insulated doors	£0.00	£504.47					per door	Number of doors
Draught proofing	£0.00	£3.57					m	Window and Door Perimeter
Reduced infiltration treatment	£22.01	£3.57					m	Window and Door Perimeter
Condensing boiler	£2,401.52	£0.00	£700.00		£5,998.31		per dwelling	Number of dwellings
Heating controls (Timer, Thermostat and TRV)	£451.71	£0.00					per dwelling	Number of dwellings
Heating controls (Timer and TRV)	£368.68	£0.00					per dwelling	Number of dwellings
Heating controls (TRVs only)	£168.84	£0.00					per dwelling	Number of dwellings
Hot Water Cylinder Thermostat	£119.99	£0.00					per Unit	Number of dwellings
Hot Water Tank insulation	£12.65	£0.00					per Unit	Number of dwellings
Halogen lamps	£0.00	£2.89					per Bulb	Number of bulbs replaceable
CFL lamps	£0.00	£5.52					per Bulb	Number of bulbs replaceable
LED lamps	£0.00	£9.80					per Bulb	Number of bulbs replaceable
Passive Flue Gas Heat Recovery	£652.79	£0.00					Number of dwellings	Number of dwellings
Smart meter (gas and electric)	£212.28	£0.00					per meter	Number of meters
Chest freezer	£270	£0.00					per unit	per unit
Fridge freezer	£278	£0.00					per unit	per unit
Refrigerator	£276	£0.00					per unit	per unit
Upright freezer	£442	£0.00					per unit	per unit
Washing machine	£321	£0.00					per unit	per unit
Tumble driers	£236	£0.00					per unit	per unit
Dishwasher	£365	£0.00					per unit	per unit
Electric ovens	£382	£0.00					per unit	per unit
TV	£542	£0.00					per unit	per unit

Hard to treat cavity type	Fixed cost	Variable cost
Narrow cavity	£250.12	£5.06
Concrete frame	£6,000.00	£111.49
Random stone	£2,400.00	£73.35
Metal construction	£6,000.00	£111.49
Timber has cavity	£6,000.00	£111.49
Wall fault	£3,083.45	£5.06
Too high	£4,000.00	£0.00
Exposed location	£250.12	£5.06

EST for DECC, *Non-standard CWI Costs*, Feb 2016

Summary of cost inputs for the estimation of non-standard cavity wall insulation costs

Wall type	Insulation type	Material costs (per m^2)	Insulation labour costs (per m^2)	Other costs	Cost to treat a semi detached
Standard cavity	Mineral wool	£1.50	£2.00		£286
Narrow cavity	EPS beads	£2.50	£2.50		£409
Stone cavity	EPS beads	£3.00	£2.50		£450
Metal frame	EPS beads	£7.80 materials and labour			£638
Concrete	EPS beads	£8.45 materials and labour			£691
Timber frame with uninsulated cavity and uninsulated studwork	EPS beads	£2.50	£4.00		£532
Timber frame without a cavity and uninsulated stud work	EPS beads	£2.50	£4.00		£532
Partial fill cavity walls	Mineral wool	£2.00	£2.00		£327
Standard cavity: Too High	Weighted (28% Mineral wool 72% PUR)	£9.07	£4.16	£17.40 (scaffolding / gondola)	£885 (for a flat)
Standard cavity: Conservatory	Mineral wool	£1.50	£3.50	£400 per dwelling scaffolding	£809
Standard cavity: Panelling On Exterior	Mineral wool	£2.00	£3.00		£409
Standard cavity: Mixed Wall Types	Mineral wool	£2.00	£3.00		£409
Standard cavity: Exposed walls	PUR	£27.50 labour and material			£2,250
Standard cavity: Structural fault	Mineral wool	£1.50	£2.00	£3,750 per dwelling to repair wall	£4,159
Standard cavity: finish fault	Mineral wool	£1.50	£2.00	£1,275 per dwelling to repair wall	£1,684
Standard cavity: DPC fault	Mineral wool	£1.50	£2.00	£3,000 per dwelling to repair wall	£3,409
Party cavity wall	Mineral wool	£2.50	£3.00		£300-350

INCA, Committee on Climate Change - Solid Wall Insulation Review, 2015
SWI Costs by Scale/Geographical Area

Estimated Proportion	Roll-out	Geographical Consideration	Fixed Cost	Variable Cost	Total Cost ($80m^2$)
10%	single home projects	Higher proportion rural	£4,000	£70/m2	£9,600
30%	under 100 home install projects	Can be rural	£2,000	£65/m2	£7,200
60%	over 100 home installs projects	Mostly urban	£1,500	£65/m2	£6,700

WWF, Mind the Gap: Funding Home Energy Efficiency to Deliver Scotland's Climate Change and Fuel Poverty Targets, 2012
Comparison of EST Housing Energy Model 2010 Costs and DEMSCOT Costs.

(The report notes that EST costs were based on discussions with trade associations, manufacturers and installers, and that DEMSCOT costs were derived from data provided by

MEASURE	CAPITAL COST (£)			ASSUMED VAT RATE	DEMSCOT COSTS[33]
	FLATS	TERRACED	SEMI/DET		
CAVITY WALL INSULATION	£ 160	£ 210	£ 621	5%	£ 500
LOFT INSULATION (POOR - 60MM)		£ 410	£ 465	5%	£ 500
LOFT INSULATION (GOOD - 165MM)		£ 336	£ 366	5%	
INTERNAL INSULATION	£ 5,256	£ 5,703	£ 7,137	5%	£ 5,500
EXTERNAL INSULATION	£ 3,834	£ 7,666	£ 11,036	5%	
FLOOR INSULATION		£ 1,675	£ 2,210	5%	
INSULATED DOORS	£ 541	£ 538	£ 538	20%	
PRIMARY PIPEWORK INSULATION	£ 101	£ 101	£ 101	5%	£ 30
DOUBLE GLAZING	£ 1,248	£ 1,560	£ 1,872	20%	£ 3,700
REDUCED INFILTRATION A - TO $5M^3/M^2.H$	£ 240	£ 240	£ 240	20%	
REDUCED INFILTRATION B - TO 1.5 $M^3/M^2.H$ (INCL. HEAT RECOVERY)	£ 3,500	£ 3,500	£ 3,500	20%	
DRAUGHT PROOFING - TO $10M^3/M^2.H$	£ 101	£ 101	£ 101	5%	£ 30
TRIPLE GLAZING (WHERE NO DOUBLE GLAZING PACKAGE ALREADY INCLUDED)	£ 1,522	£ 2,134	£ 2,134	20%	
LOW ENERGY LIGHT BULBS	£ 10	£ 20	£ 28	20%	£ 60
HEATING CONTROLS	£ 419	£ 419	£ 419	5%	£ 300
INSULATED DOORS	£ 444	£ 444	£ 444	20%	
FOAM INSULATED DHW CYLINDER	£ 1,446	£ 1,446	£ 1,446	20%	£ 2,500
CONDENSING BOILER REPLACEMENT (GAS)	£ 3,500	£ 5,000	£ 6,500	5%	£ 8,400
HEAT PUMP (AIR SOURCE)	£160	£160	£160	£160	£160

CAR, RICS and interviews with Scottish contractors)

Appendix B: Acknowledgements

We are very grateful to the following organisations for contributing their time and providing data for this study, as well as to the other participating organisations who chose to remain anonymous.

1st Choice Insulations

A1 Warmcare Insulation

Aran Services Ltd

Aston Cord

British Gas

City Sound Glazing

Eco Matters

Extraglaze Ltd

Foamseal

Green Heat

Heating Britain Ltd

Imperial Windows

InstaGroup Ltd

Intelligent Global Power

K. & E. Peck Ltd

Knauf Insulation

Lapolla UK

Lawtech Group

Liquid Plumbing Solutions Ltd

LRB Plumbing and Heating

Make My Home Green

Mark Wood Heating Ltd

O'Connell's Drywall Contractors Ltd

Orion Insulation

Public Health England

Pioneer Wall Cladding and Building Insulation Ltd

Renov8tions Ltd

Retrofit UK Ltd

S.D.Roberts Plastering Specialist

Six Star Insulation

Solarwall Ltd

Sovereign Group

Suffolk Installers

Team Frames Trade and Retail

The Green Age

The Warmer Group

Titan Insulations Ltd

Urbane-Eco

Vista Home Improvements

Wall-Lag Ltd

Warmseal

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