Quantification of non-standard cavity walls and lofts in Great Britain:

Understanding the number of dwellings with unfilled non-standard cavity walls and lofts in Great Britain, and information on how these might be insulated

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Document information

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Responsible author(s):	Greg Shreeve Senior Consultant, Consulting, Energy Saving Trust phone: 020 7222 0101 email: greg.shreeve@est.org.uk
	Joe Payne Lead Analyst, Consulting, Energy Saving Trust phone: 020 7222 0101 email: joe.payne@est.org.uk
Reviewer(s):	Will Rivers Future Markets & Product Development Manager, Energy Saving Trust
	Simon Messenger Head of Consulting, Energy Saving Trust

Summary of research findings

Cavity wall and loft insulation have played an integral part in schemes to improve the thermal performance of the housing stock of Great Britain. The retrofitting of cavity walls and loft insulation has left a diminishing number of further walls and lofts to be insulated. Furthermore, an increasing proportion of the remainder of fillable lofts and cavity walls will be non-standard, by which it is meant that something of the construction of the wall or loft means ordinary methods of insulation may not be applicable. Cavity walls and lofts of non-standard types may be more costly than standard walls to insulate and insulation may not save a comparable amount of energy to insulation of 'standard' types.

This report investigates the reasons that make a cavity wall or loft non-standard and quantifies, where possible, the estimated number of non-standard walls and lofts in Great Britain. In addition, we consider the costs associated with insulating different types of non-standard cavity walls and lofts and the resulting carbon savings.

Key findings

1. There are likely to be more fillable standard cavity walls than DECC presently estimate

DECC's latest figures estimate that there are at least 400,000 easy to treat (i.e. standard) fillable cavity walls, and at most a further 500,000 "uncertain" walls of which some may also be easy to treat[1]. Our estimates suggest that there are between 2.3 and 2.4 million standard cavity walls which could be insulated at low cost which are currently uninsulated. Further information about the reasons for the differences in this estimate can be found in Appendix 4. In addition to this there are around 1.3 million uninsulated walls with cavities that are non-standard construction (e.g. concrete, stone, narrow cavity etc.) and a further 2.2 – 2.4 million dwellings that have a standard masonry cavity, but have issues that that need special attention (e.g. wall faults, exposure issues or access issues) and therefore would be more expensive to insulate.

2. It may not be possible to generalise how to insulate different types of non-standard cavity walls and lofts.

Through our survey of stakeholders and workshop, we found differing opinions on what materials were and were not suitable for different types of non-standard walls. In general, there were concerns that the use of inappropriate insulation material may lead either to issues caused by cold patches or excessive moisture such as damp, mould or rot. For both walls and lofts stakeholders emphasised the need to assess properties on a case by case basis with attention to the effects of insulation to ventilation and thermal bridging.

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[1] The uncertainty in the DECC figures is due to potential under reporting of insulation in the housing surveys. Source: Green Deal, Energy Company Obligation (ECO) and Insulation Levels in Great Britain, detailed report: to June 2015. Available at: https://www.gov.uk/government/collections/green-deal-and-energy-company-obligation-eco-statistics; [accessed Feb 2016]

3. **Not all types of non-standard wall can be quantified through the housing surveys in Great Britain.**

Our discussions with stakeholders revealed a number of types of non-standard cavities and lofts that could not be quantified using the GB housing surveys (such as the English Housing Survey). For instance, it is not possible to identify homes with “rat-trap bond” cavity walls, as data is not collected on the configuration of brickwork. For many non-standard wall types in this report, we infer from combinations of variables within the housing surveys and secondary data sets the numbers of non-standard walls and lofts where possible. In some instances, stakeholders thought that these estimates were too low. However upon further investigation no alternative data sources were available to provide better estimates.

4. **Many walls and lofts previously insulated may not have had appropriate installations**

Many amongst the project’s stakeholder group claimed to have observed many instances of walls that had been insulated but with either material that was unsuitable, or where the wall had not been sufficiently filled (therefore leaving cold spots on the wall). It was even noted that there were instances where walls had been recorded as having been insulated, with evidence of bore holes being drilled through the walls, but that the cavities had not been filled. For future insulation policies and programmes it is vital to consider how to ensure adequate consultations and inspections are carried out, to ensure insulation is installed to an appropriate and good quality standard.

Headline results

Non-standard cavity walls

In this project we define non-standard cavity walls as those that may be more costly than standard cavity walls to fill and / or that when insulated may save less energy. We define two broad categories of non-standard cavity walls:

1) Non-standard construction cavity wall - a construction type is non-traditional (for instance has a concrete frame) or, has narrow or irregular cavity

2) Standard cavity walls with issues - a standard masonry cavity but with issues such as height, access, exposure or faults that make insulation more expensive

Table 1 provides figures for our estimates of the total number of walls in Great Britain that meet each category of standard and non-standard cavity walls and the number that are fillable and insulated or unfillable. By fillable we mean that some form of cavity insulation could be applied to the wall.

Table 1 – Number of dwellings with standard and non-standard walls in Great Britain

Wall type	Total (000s)	Insulated or unfillable (000s)	Fillable (000s)
Standard Cavity	**8,500-8,800**	**6,200-6,400**	**2,300-2,500**
Non Standard Cavity	**10,900-11,200**	**7,300-7,500**	**3,500-3,800**
Standard Cavity With At Least One Issue:	8,430-8,720	6,100-6,360	2,250-2,430
Issue: Finish Fault	2,534 - 2,717	1,615 - 1,764	879 - 992
Issue: Too High	746 - 851	247 - 309	478 - 563
Issue: Panelling On Exterior	1,775 - 1,931	1,318 - 1,454	427 - 507
Issue: Conservatory	2,482 - 2,663	2,071 - 2,239	379 - 455
Issue: Mixed Wall Types	971 - 1,090	613 - 709	334 - 406
Issue: DPC fault	1,008 - 1,128	798 - 906	188 - 243
Issue: Structural Fault	500 - 586	362 - 437	121 - 166
Issue: Exposed Wall	610 - 706	552 - 642	46 - 76
Partially Filled Cavity Wall	Not quantified	Not quantified	572 - 664
Narrow Cavity	494 - 580	309 - 378	168 - 220
Timber Frame Solid With Fillable Studwork	Not quantified	Not quantified	127 - 173
Concrete Construction	572 - 665	438 - 519	118 - 162
Timber Frame Cavity With Fillable Studwork	Not quantified	Not quantified	104 - 146
Metal Frame	119 - 164	110 - 153	4 - 15
Stone Cavity	267 - 332	197 - 253	58 - 90
Other Walls	**7,300 - 7,600**	Not quantified	Not quantified
Party Cavity Wall With Bypass	Not quantified	Not quantified	**5,980 - 6,240**

Table 2 provides estimates of the cost and carbon savings associated with filling each category of standard and non-standard cavity wall appropriately. This means the total cost of the job including material costs, rectifying wall issues and installing scaffolding etc. To note, we found some conflict of opinions amongst stakeholders about what solutions were appropriate for different wall types and the associated costs. If further resources are made available for this project we intend to improve these costs with a set of quotes for specified jobs from installers.

Table 2 – Associated costs and carbon saving for insulating non-standard walls in Great Britain

Wall type	Number of dwellings (000s)	Cost to treat (£M)	CO_2 saving (kTCO_2 / yr)	Average cost per home	Average CO_2 saved per home (T CO_2 / yr)
Standard Cavity	**2,300 - 2,480**	**£612 - £658**	**1,100 – 1,200**	**£266**	**0.48**
Non Standard Cavity	**3,550 - 3,760**	**£5,530 - £5,860**	**1,500 – 1,600**	**£1,561**	**0.43**
Standard Cavity With At Least One Issue:	2,250 - 2,430	£4,890 - £5,270	1,200 – 1,200	£2,172	0.51
Issue: Finish Fault	879 - 992	£1,450 - £1,630	410 - 460	£1,645	0.47
Issue: Too High	478 - 563	£435 - £512	130 - 160	£911	0.28
Issue: Panelling on Exterior	427 - 507	£137 - £162	180 - 210	£320	0.42
Issue: Conservatory	379 - 455	£394 - £474	270 - 330	£1,041	0.72
Issue: Mixed Wall Types	334 - 406	£125 - £152	160 - 190	£374	0.47
Issue: DPC Fault	188 - 243	£643 - £831	97 - 120	£3,423	0.51
Issue: Structural Fault	121 - 166	£496 - £680	53 - 73	£4,093	0.44
Issue: Exposed Wall	47 - 76	£121 - £197	26 - 43	£2,602	0.57
Partially Filled Cavity Wall	572 - 664	£235 - £273	29 - 34	£411	0.05
Narrow Cavity	168 - 220	£60.2 - £78.9	69 - 91	£359	0.41
Timber Frame Solid With Fillable Studwork	127 - 173	£96.7 - £132	60 - 82	£761	0.47
Concrete Construction	118 - 162	£38.0 - £52.3	28 - 38	£323	0.24
Timber Frame Cavity With Fillable Studwork	104 - 146	£63.7 - £89.3	46 - 64	£610	0.44
Metal Frame	4 - 15	£2.45 - £10.1	1.5 - 6	£659	0.39
Stone Cavity	58 - 90	£39.4 - £61.4	37 - 58	£680	0.64
Other Walls	**7,290 - 7,570**	Not quantified	Not quantified	Not quantified	Not quantified
Party Cavity Wall With Bypass	**5,980 - 6,240**	**£2110 - £2200**	**490 - 510**	**£352**	**0.08**

Non-standard lofts

Non-standard lofts are defined as those which cannot be most straightforwardly or effectively insulated – making them less cost effective to treat. This is due to the conventional solution of laying mineral wool between and across joists at ceiling level being unsuitable, or made difficult by other issues in the loft space.

We identify three broad issues which might prevent a property from receiving “standard” loft insulation: roof and loft construction; remedial and access issues; and external features including roof covering.

Table 3 summarises the headline estimates for each area of quantification: the total number of each loft type in GB (filled and unfilled); the indicative total cost of insulating remaining non-standard lofts in GB and the typical cost per dwelling; and the total carbon saving potential that might be achieved by insulating non-standard lofts in GB, and the average carbon saved per dwelling.

These estimates are broadly in line with the most recent DECC published estimates of remaining insulation potential in Great Britain, although the estimates modelled in this study suggest that a number of uninsulated “easy to treat” dwellings may have access issues, which make installing insulation material more costly.

The work required to install improved insulation on a non-standard loft is considerably higher than conventional loft insulation. The cost estimates presented in this study draw on a wide range of sources, including installed quotes, they are generalised, indicative costs derived for the purposes of modelling. An extension to this study dealing specifically with cost has been commissioned and this should be consulted for a more robust assessment of cost.

However, since the use of a loft as a habitable space increases the heat loss area of a dwelling, the potential carbon savings achievable are higher than installing standard insulation at ceiling level to a comparable thermal performance.

Structural and roof covering faults may also generate additional cost to the task of reducing roof heat loss cost effectively, and may lead to damaged insulant in already treated dwellings. We estimate that as many as 15% of GB dwellings may have some type of roof fault, particularly amongst dwellings constructed before 1945.

Table 3 – Headline estimates for standard and non-standard lofts in Great Britain

	Type of loft	Estimated range (000s)	Cost to treat: All dwellings (£M)	Cost to treat: Per dwelling	Carbon savings potential / yr: All dwellings $kTCO_2$	Carbon savings potential / yr: Per dwelling TCO_2
All GB homes	No loft	3,212 - 3,413				
All GB homes	All fully insulated	16,700 - 16,986				
All GB homes	All insufficiently insulated or uninsulated	6,504 - 6,766				
Insulation potential	All standard lofts, insufficient insulation	4,186 - 4,410	£796.2 - £905.9	£150 - £280	323.6 - 3,080.2	0.08 - 0.67
Insulation potential	All non-standard, uninsulated	2,251 - 2,423				
Non-standard insulation potential	Standard lofts with access issues, uninsulated	1,046 - 1,168	£338.0 - £432.2	£300 - £430	76. - 820.2	0.08 - 0.66
Non-standard insulation potential	Flat roof uninsulated	247 - 308	£315.3 - £510.3	£1060 - £1960	260.7 - 410.6	1.21
Non-standard insulation potential	Room-in-roof uninsulated	599 - 692	£793.3 - £1,100.8	£1070 - £2250	506.6 - 712.5	0.94
Non-standard insulation potential	Mansard roof uninsulated	53 - 84	£63.5 - £214.4	£1360 - £3510	35.5 - 115.5	1.10
Non-standard insulation potential	Chalet roof uninsulated	121 - 166	£183.6 - £291.8	£960 - £2110	128.3 - 204.3	1.16
Non-standard insulation potential	Mixed roof types uninsulated	76 - 113				

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1 Introduction

Cavity wall and loft insulation have played an integral part in schemes to improve the thermal performance of the housing stock of Great Britain. The retrofitting of cavity walls and loft insulation has left a diminishing number of further walls and lofts to be insulated. Latest DECC data[2] estimates that there are fewer than 4.7 million uninsulated cavities and 7 million homes with lofts that could benefit from further insulation.

Within this remaining potential there are many non-standard cavity walls and lofts. Non-standard cavity walls and lofts are those that would be either more expensive to insulate or that by doing so would be would save less carbon than insulating a standard wall or loft. As loft and cavity wall insulation is more cost effective in easy to treat dwellings these are the dwellings that are more likely to be insulated. Therefore an increasing proportion of homes that could benefit from cavity wall or loft insulation will be non-standard.

In 2010, DECC commissioned Davis Langdon and Inbuilt to undertake research into the types of non-standard cavity walls in the Great Britain and how these could be insulated. This was followed up with further research in 2012 to quantify the numbers of non-standard cavity walls and the carbon saving potential from treating these. This research builds on this work, with the inclusion of non-standard lofts and bypass party cavity walls to develop a practical methodology for classifying, quantifying and estimating the cost effectiveness of treating non-standard cavity walls and lofts.

In this report we investigate the reasons that make a cavity wall or loft non-standard and where possible, the estimated number of non-standard walls and lofts in Great Britain. In addition, we consider what approaches are suitable for insulating these walls and lofts as well as the associated costs of insulating these walls and lofts and the resulting carbon savings.

[2] Domestic Green Deal, Energy Company Obligation and Insulation Levels in Great Britain, DECC (17th September 2015). Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/461160/National_Statistics_Detailed_Release_-_GD___ECO_in_GB_Sep15_Final.pdf; [accessed Oct 2015]

2 Research approach

Evidence gathering and analysis for this project was split into two stages, both centred on input from industry stakeholders. This was to ensure that industry experience is captured and quantified, that newly available solutions are captured in the analysis, and that results and assumptions are validated and refined.

Figure 1 summarises the data collection and analytical tasks under each stage of the project. In this interim report, we present findings from these Stage 1 tasks. These answer the first of the key targeted outputs of the study:

1. Review the categorisations of non-standard cavities and lofts in light of new evidence and experience.

The data collected in this stage establishes the inputs to the analytical and validation tasks in Stage 2, and will inform targeted outputs 2-5:

2. Identify the number of dwellings in Great Britain with lofts and cavities and with each category of non-standard loft and cavity.
3. Provide a breakdown of the number of non-standard cavities and lofts by property type and property age.
4. Estimate, for all fillable categories of non-standard cavity and loft, the costs of insulation and the energy savings from insulation.
5. Provide a report detailing the impacts of this analysis in terms of the overall UK housing stock.

The key principles underpinning EST's analytical approach are to:

1. Gain maximum value from existing research, categorisations and methodologies; improving and updating these where necessary.
2. Use methodologies and data that will enable DECC to update the analysis at regular intervals in the future.
3. Document all assumptions and methodologies clearly to ensure transparency in approach.
4. Use the desk-based research to gather initial assumptions which can then be refined and updated through consultation with industry.
5. Use the consultation with industry to address major gaps in the existing literature, for example in collecting up-to-date information on the costs of non-standard solutions and the availability of new products not considered in previous literature.

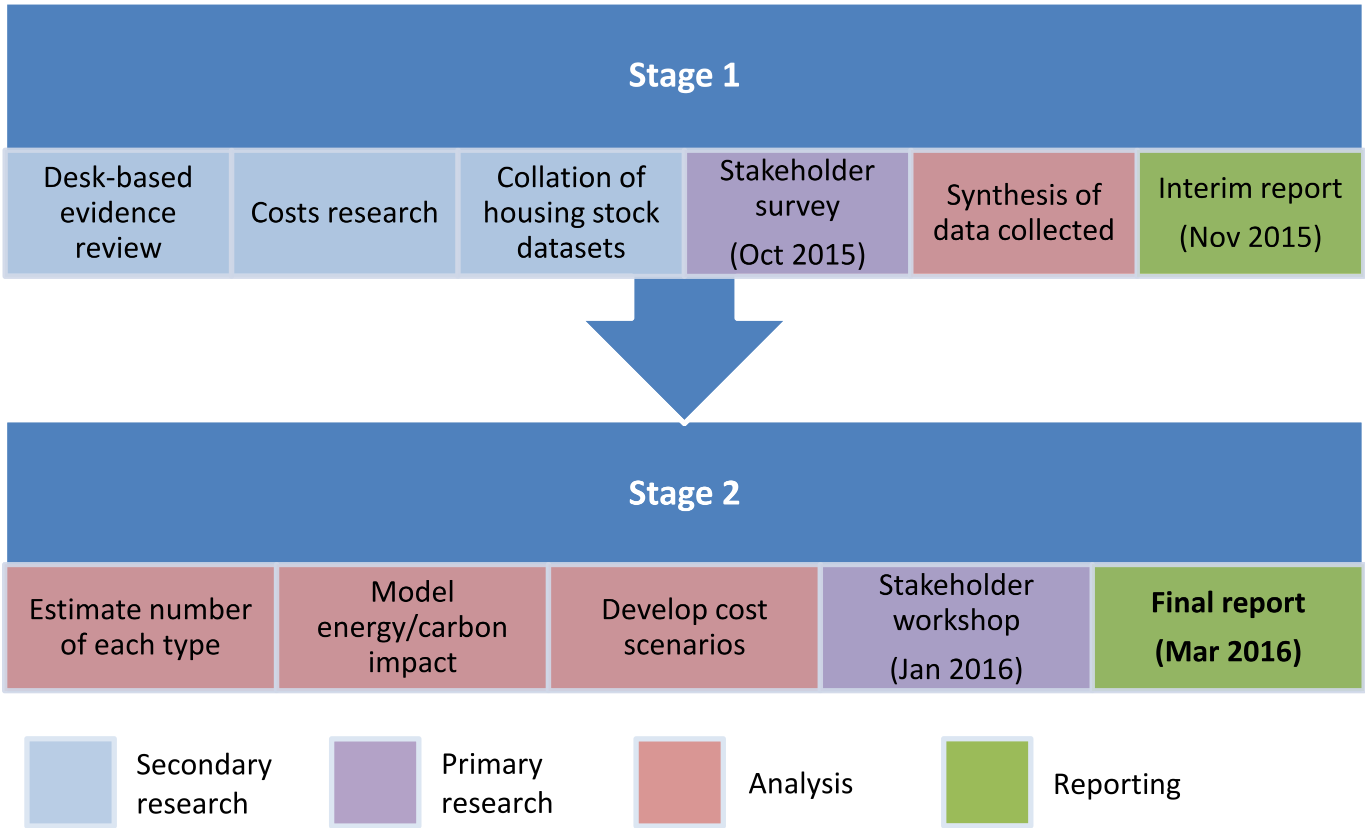

Figure 1 – Overview of project data collection and analysis stages

2.1 Stakeholder survey

As part of the evidence gathering for this research, an online survey for stakeholders was commissioned. The questionnaire was developed to verify and cross check evidence gathered in the literature review and to seek out new data.

The survey asked questions about non-standard cavity walls and lofts that:

- Confirmed that previously identified wall and loft types were non-standard
- Established whether there are further types that should be considered non-standard
- Assessed what materials and processes are suitable for insulating these walls and roofs
- Identified and materials that are unsuitable
- Identified any wall and roof types that should be filled / insulated
- Gathered costs of insulating wall and roof types

The survey was emailed out to 114 individuals from across 95 organisations. Some stakeholders sent the survey on to other potential respondents from additional organisations. Stakeholders included:

insulation certification bodies, Energy Company Obligation (ECO) managers, the Cavity Insulation Guarantee Agency (CIGA), installers, insulation manufacturers, local authority energy efficiency scheme managers, trade associations and other energy efficiency experts.

2.2 Stakeholder workshop

The workshop consisted of a presentation of the headline figures from the methodology report, plus information about how we had classified the number of walls of each category. Following on from each discussion, the attendees were asked in groups to discuss the following questions:

Categorising non-standard walls and lofts:

1. Why should these walls and lofts be considered non-standard?
2. Are there any other wall types which should be classified as non-standard? Why?
3. Are there any other loft types which should be classified as non-standard? Why?
4. Are there any ways in which we can improve our estimates of the number of these dwellings in GB?

Suitable solutions and the cost of these:

5. What available solutions are suitable for each wall and loft type? Are there any new solutions that should be considered?
6. Do the cost estimates presented seem accurate? Are there any additional costs being overlooked?
7. Are there any ways in which costs can be reduced?

2.3 Further work beyond this report

At the stakeholder workshop in January 2016, the methodology and preliminary results of the housing stock, carbon and cost modelling analysis were shared with peers (see Appendix 2 for a list of attendees) in order to be critically reality-checked. One of the areas in which the methodology was identified as weaker was around the cost estimates developed for this report. These bring together quotes from installers, manufacturers and scheme managers provided to the stakeholder survey, information from industry pricing books[3,4], and data held in the Energy Saving Trust Cost Database[5] from previous secondary cost research. However, the feedback was that since an improved understanding of

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[3] Davis Langdon (2013): SPON's Architects' and Builders' Price Book 2013. Spon Press, 138th ed.
[4] Spain, B. (2010): SPON's House Improvement Price Book. Spon Press, 4th ed.
[5] This is a cost database resource maintained by EST, which brings together evidence from installer quotes, secondary internet and literature research, price book estimates, and cost data from retrofit schemes.

the real cost of treating non-standard dwellings was an important output of this research, a more detailed cost gathering exercise which went into more detail was appropriate.

In response to this, EST proposed a piece of work extending this study to DECC. This extension is planned to be carried out in 2016 with the aim of deriving a more robust and detailed schedule of costs. The proposed approach is summarised in Figure 2. The motivation for extending the cost research to include these additional stages is to achieve a fully-specified, standardised cost schedule in order to improve compatibility across estimates from different sources. By having industry standard specifications of insulation jobs, before having these quoted for by installers, this exercise will reduce variation in cost driven by differences in interpretation of the type and extent of work required.

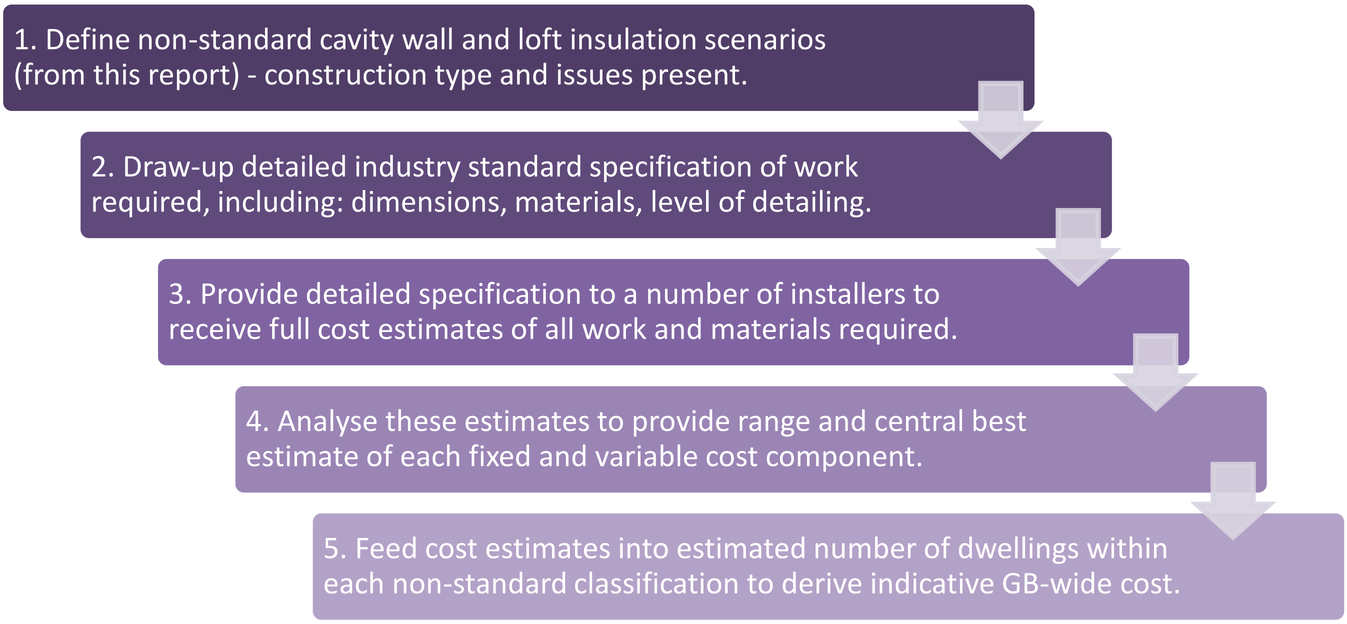

Figure 2 – Summary of non-standard insulation cost extension

3 Non-standard cavity walls: identification and treatment

3.1 Classification of non-standard cavity walls

The scope of this research has included all types of cavity walls on dwellings that would be more expensive to insulate than standard cavities and/ or would save less energy when insulated than a standard cavity wall.

As part of this research we have only looked into insulation solutions that involve filling the void in the wall. The research has not looked into either internal or external wall insulation as a solution. It is possible that in some cases either of these solutions may be more appropriate or cost effective than cavity wall insulation however this investigation does not fall within the scope of this project.

We identified a list of numerous non-standard cavity walls within the literature review, stakeholder survey and workshop. There are two classes of these non-standard walls: *non-standard construction cavity walls* and *standard cavity walls with issues*. The former includes walls with non-traditional constructions (such as a concrete frame or narrow cavity). The latter class consists of standard masonry cavity walls whereby an issue such as a wall fault or access problems leads to insulation being more expensive to install.

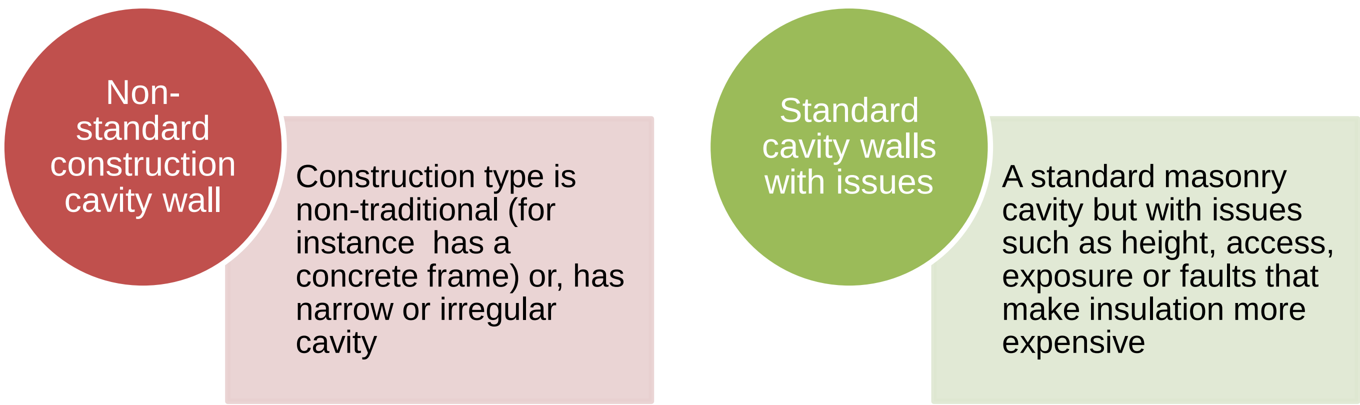

Figure 3 – Defining "non-standard" cavity walls

We set out below a description of each type of non-standard wall identified. It was not possible to quantify every non-standard wall type with the data available. Table 4 sets out which classes of non-standard cavity walls have been quantifiable as part of the report and that for which no sufficient data was available.

3.1.1 Non-standard construction cavity walls

Narrow cavity: these are masonry cavities where the minimum distance between the inner leaf and the outer leaf is less than 50mm. This issue makes a wall non-standard for several reasons: because of the cavity's width it can only be filled with a limited amount of insulate, therefore the energy saving is smaller. Furthermore greater attention needs to be paid to the potential of moisture penetration from the outside as there is a reduced distance between the exterior and interior of the wall, particularly in exposed locations.

Stone cavity: these walls have exterior courses made from stone. The inside face of the cavity may not be uniform which can affect how evenly certain insulation materials are distributed when a cavity is insulated. The stone may also make access points difficult for injecting the insulation.

Metal frame: these are walls where the inner structure is formed using a steel frame. In some instances it may be possible to insulate the void formed between the inner leaf and outer brickwork. However stakeholders raised concerns about whether in general it is possible to insulate dwellings with this type of construction. Without specific information about the nature of each wall, inappropriate application of insulation could risk degradation of the metal frame.

Concrete construction: system build walls where walls are made from panels pre-formed ahead of construction off site. Some of these may have voids within the wall that could be filled. This was another wall construction where stakeholders were concerned about whether generalisations could be made about the suitability of these walls for insulation.

In addition, some concrete structures where concrete is cast on site (such as "no-fines") could be insulated. In general such structures do not have fillable voids; however some dwellings with a masonry outer leaf will have a cavity between the inner concrete leaf and the outer brickwork which may be fillable.

Cavity with concrete floor structure: prevalent in high rise flats, Concrete floors at various stories protrude into or through the cavity to the outer leaf of the building. The support of the floor structure can make the cavity easier to insulate than in most high rise buildings, however the floor creates a thermal bridge which diminishes the potential saving.

Partially filled cavities: walls with rigid insulation board filling part of the width of the cavity. These walls were prevalent in constructions built during the 1980s and later. There are cases where insulation has not been fully secured to the interior wall of the cavity. This reduces the thermal performance of the wall and also makes installing new further insulation problematic.

Timber frame construction with masonry cavity and uninsulated studwork: these are timber frame walls with masonry cavities. It is generally not recommended to insulate the masonry cavity as this may lead to the timber frame rotting. However the studwork on the inner leaf of the wall may be filled. **Error! Reference source not found.** shows an example of this.

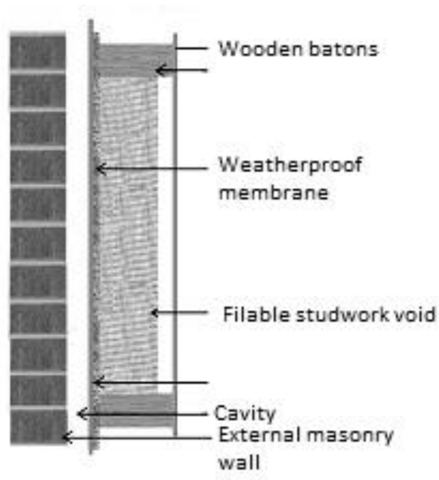

Figure 4 - Timber frame construction with masonry cavity and uninsulated studwork

Timber frame with uninsulated studwork but without masonry cavity: are the same as "timber frame construction with masonry cavity walls and uninsulated studwork" as detailed above except that there is no cavity between the stud-wall and the masonry walls. In theory the studwork of these walls may be filled.

Lath and plaster and other micro-cavities: a solid mass wall typically with a void between the wall and the internal lath and plaster finish generally around 40mm wide or less. These generally show up in housing surveys as solid walls. It was mentioned in our stakeholder workshop that the cavity may reduce the effectiveness of external wall insulation due to the bypass effect. This is where an unsealed cavity causes heat loss by transferring heat from the walls to an unheated space in the loft through convection in the cavity.

Rat trap bond cavities: some early construction cavity walls were built with bricks that connecting the interior and exterior leaf of the cavity. Insulating these walls can lead to moisture problems. With a clear cavity, moisture on the brick bond can dry out. However, with insulation in the cavity, this may cause moisture to travel from the outer to inner leaf along the adjoining brick, causing damp issues.

3.1.2 Standard cavity walls with issues

Mixed construction: these include walls where part of the construction may be a standard cavity, but other walls within the building or on other stories are solid. This means that cavity wall insulation is possible only in part of the dwelling, which means the energy saved will be less than applying cavity wall insulation to a home constructed entirely with standard cavity walls.

Tile hanging or other cladding on wall: these are walls with tiles or other external cladding would need to be removed in order to allow a borehole to be drilled for insulating the cavity. This extra work adds further expense to the job of insulating the walls.

Wall faults - structural, finish or damp proof course: dwellings where the outer face is damaged – for instance spalled bricks or faulty pointing. This may lead to water penetrating into the cavity, which when insulated could cause moisture problems. Other faults include faulty damp proof courses.

Sealant failure around doors and windows: a common issue with standard cavities can be deteriorated sealant around doors and windows. This must be treated before insulation takes place so as to prevent moisture ingress into the cavity.

Cavities with double leaf exterior wall: it was noted by our stakeholders that some cavity walls appear from external inspection to be solid walls. An example was give of an estate in London where the exterior wall of the cavity had been constructed using Flemish bond construction. Without closer inspection these homes could be assumed to have solid walls when in fact they are cavity walls. These walls can be insulated as standard cavities, but will require a longer injection nozzle to reach the cavity void.

Rubble in cavity: in some cases construction rubble is present within uninsulated cavities. This must be cleared out before insulating a wall and adds additional cost to the insulation process.

Faulty Finlock gutters: Finlock gutters are built-in concrete gutters that sit above the cavity. Our stakeholder group noted that these often leak moisture into the cavity if the lining is poor quality or has deteriorated over time. They are also likely to cause a cold bridge through the concrete into the cavity, or bypassing the top of the cavity wall – which would diminish the savings achieved by insulating.

Too high: not all forms of insulation are guaranteed to work above a certain height. The height restricts insulation options to specific materials, or may require scaffolding or gondolas to perform the insulation.

Access issues: dwellings with obstacles that make it difficult to bring machinery required up close to insulate the cavity. For instance homes with conservatories on the outside. These might require scaffolding around the obstruction in order to fill the wall.

Distance from road: it was noted that dwellings that are a considerable distance from a road (100m or more) can be more expensive to insulate as specialist access equipment would be required.

Exposed locations: walls in areas where driving rain may cause water to migrate across the cavity to the inner leaf if the cavity wall is insulated.

Flood risk locations: the project stakeholder group noted that homes in flood risk areas should not be insulated with blown mineral wool as this could lead to water being held within the cavity after flooding, leading to later damp issues. These walls could therefore be classified as non-standard. However some stakeholders suggested that regardless of what material is used to insulate these walls that any insulation would need to be removed from a cavity after flooding, because of the need to get rid of effluent waste that could get trapped. There may be more complete solutions which include flood proofing doors and windows, and other entry points to the home, which along with a polyurethane (PUR) fill may enable a property with high flood risk to receive cavity wall insulation. However the expense of such a procedure may be too high to make this a cost effective solution.

3.1.3 Party cavity wall with bypass

Party cavity walls have also been included within this analysis as an additional non-standard cavity wall. Heat loss through party cavity walls has been recognised as an important issue to tackle by government, with the inclusion of party cavity wall insulation in the ECO. Figure 5 – Heat loss mechanism in party cavity walls produced by DCLG[6] indicates the heat loss mechanism in party cavity walls.

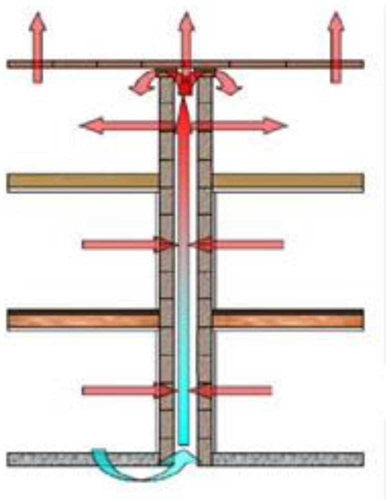

Figure 5 – Heat loss mechanism in party cavity walls

Cold air enters through the ground into the cavity. Heat from inside the home warms the cool air within the cavity. As the air warms it rises until it is vented into the unheated loft space. This creates a convection current, causing a flow of cold air sapping heat from within the dwelling through the party walls.

Evidence gathered by Bridgewater Surveyors observed several types of party wall. In some homes it was observed that some homes with party

[6] DCLG image of party wall bypass from Part L consultation presentations (2009).

cavity walls were solid above the roof level – effectively capping the top of the cavity. These may be referred to as partial bypass party walls. For these walls this heat loss effect will be reduced. The insulation of partial party cavity walls has is not included as a measure covered by ECO. It is also not quantified within this report.

Table 4 provides a list of non-standard cavity wall types that we have been able to identify sufficient data to estimate total number in Great Britain.

Table 4 – Summary of number of non-standard cavity wall dwellings that have been quantified in the final estimates of this report

Quantifiable	Insufficient data to quantify
Narrow Cavity	Cavity with concrete floor structure
Stone Cavity	Lath and plaster and other micro-cavities
Metal Frame	Rat trap bond cavities
Concrete Construction	Distance from road
Partially Filled Cavity Wall	Rubble in cavity
Timber Frame Cavity With Fillable Studwork	Faulty finlock gutters
Timber Frame Solid With Fillable Studwork	
Party Cavity Wall With Bypass	
Issue: Mixed Wall Types	
Issue: Panelling etc On Exterior	
Issue: Access due to Conservatory	
Issue: Too High	
Issue: Structural Fault	
Issue: Finish Fault	
Issue: Exposed Wall	
Dwellings in flood risk areas	

3.2 Insulating non-standard walls

Our survey and workshop with stakeholders investigated the suitability of six wall insulation materials for each category of non-standard cavity wall. These materials were:

- Mineral wool (such as glass wool or rock wool)
- Loose cellulose fibre
- Expanded polystyrene beads
- Vermiculite or perlite beads
- Polyurethane foam

- Urea formaldehyde

As explained in our results below, agreement was mixed about the suitability of each material for different wall types.

3.2.1 Mineral wool

Mineral wool can be used to fill walls via both internal and external installation. Rock wool with a λ value of 0.039 $Wm^{-1}K^{-1}$ performs slightly better than glass wool (λ = 0.04 $Wm^{-1}K^{-1}$). Both forms are BBA Certified and can be CIGA guaranteed. It is not always recommended by manufacturers on heights greater than 12m. BBA certificates require special height restriction waiver for installations above this height. This requires the BBA certificate holder (i.e. the manufacture) must assess whether an installation is suitable in each instance and document the approval prior to the work commencing. Nonetheless the Inbuilt/Davis Langdon report suggests it can be used up to 25m above ground. The material is vapour permeable and also has the potential to allow water to transfer across cavities and also to retain water. To be installed the material requires relatively large 25mm holes to be drilled into the leaf.

Previous research has suggested that mineral wool is not a suitable solution for many non-standard cavities. Due to mineral wool's ability to wick and store moisture it should generally not be suitable for homes in exposed locations – however 29% of respondents identified this material as suitable for these walls suggesting a lack of unanimity on this point.

Exposure to driven rain is a particular consideration for homes with narrow cavities as the water ingress has less distance to travel before reaching the inner leaf. If a narrow cavity is insulated with a water permeable material like mineral wool then it is more susceptible to penetrating rain being wicked through walls (i.e. the moisture can travel through the insulation material like melted wax through a candle wick). Therefore careful consideration should be taken of the maximum recommended exposure zone where the material can be installed. Only 37% of respondents said that this measure was suitable for homes with narrow cavities and only 29% said the material is suitable in cavities in exposed location - suggesting that in general the material is not suitable for these wall types.

The Davis Langdon/Inbuilt report identifies the risk of mineral wool insulation not settling evenly throughout the cavity. Furthermore with time the material can settle creating uneven distribution leading to areas with poor insulation and cold spots. In stone cavities, the uneven shape of the inner leaf can lead to uneven distribution of material if insulated with mineral wool. Only 28% of respondents to our survey said that mineral wool was suitable for stone cavity walls – suggesting that generally this material is not recommended for these wall types. Furthermore only 33% said that the material was suitable for insulating lath and plaster walls – these walls have only a very narrow small space between them making the prospect of even distribution of the materials in these walls unlikely.

The majority of respondents agreed that the measure is suitable for partially filled cavities, insulating between the studwork of timber frame walls without masonry cavities and standard cavities with access issues, cladding and mixed wall types. There was mixed responses as to whether it should be suitable for metal frame, concrete walls, or high-rise homes with protruding floor structures.

Whilst manufacturers do not always recommend that mineral wool is installed in the walls of cavities above 12m, 67% of respondents to our survey stated that this was suitable in homes above 3 storeys.

3.2.2 Loose cellulose fibre

Cellulose loose material can be blown in to fill a cavity wall using high pressure injection using a 25mm hole. It is made from recycled materials including paper and is vapour permeable. It has a similar conductivity to mineral fibre $\lambda = 0.039\ Wm^{-1}K^{-1}$ and is BBA Certified to insulate between timber frame studs. As this material is generally used as an insulation material for studwork it is applied to the cavity via the internal leaf.

Online review of solutions suggests that cellulose loose fill insulation is not commonly used for retrospectively insulating wall types other than timber frames. Some products[7] are marketed exclusively as a solution for timber frame walls. It is vapour and moisture permeable so would not be suitable for walls where the cavity is susceptible to water penetrating into the cavity (i.e. high exposure and flood risk zones). The material is not covered by CIGA Guarantee.

Although the literature review suggests that installers have systems to ensure that cellulose loose fill insulation distributes as evenly as possible, the material is loose fill and therefore even distribution may not be guaranteed, especially in wall types other than stud walls.

As with all loose fill insulates, barriers are required between adjoining buildings and care needs to be taken to ensure holes in the walls are properly sealed to prevent the material leaking out of the wall.

As part of our survey cellulose insulation was rarely recommended as suitable for many wall types. Only 40% of respondents said that this product was suitable for walls with timber uninsulated without masonry cavities and 33% said it was suitable for timber frames with masonry cavities – despite this being what the product is specifically designed to insulate. EPS, blown mineral wool and polyurethane foam were recommended more often as suitable for this wall type. This may indicate that there is lack of familiarity with this product from much of the respondents. This however may be due to lack of familiarity of respondents with the product, rather than anyone reporting any known problems with the material.

In summary the findings suggest that this is an insulation material suitable primarily for timber frame walls.

3.2.3 Expanded polystyrene beads

Expanded polystyrene (EPS) beads can be applied to the cavity via both the internal and external leaf). Different EPS beads have differing thermal conductivity levels, from around $\lambda = 0.045\ Wm^{-1}K^{-1}$ to $0.032\ Wm^{-1}K^{-1}$. There are many BBA Certified EPS systems that are also CIGA guaranteed. The material is vapour permeable and moisture resistant. To be installed the material requires relatively large 25mm holes to be drilled into the outer or inner leaf. The tops of cavities generally need to be sealed to prevent the material being blown out.

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7 For example, Warmcel. See online at: http://www.warmcel.co.uk/installation/walls/; [accessed Oct 2015]

A review of existing literature suggests that EPS is suitable for most standard and non-standard cavities. The material has to be carefully installed to prevent static electrical clinging of the beads to each other causing an uneven distribution and cold spots. Due to these distribution issues, as highlighted in the Inbuilt/Davis Langdon report the main wall type that this insulate would not be recommended for are stone cavity walls. Some EPS beads products can be used in narrow cavities (with a width less than 50mm) although suitability varies between products.

Because EPS beads are moisture resistant they will not aid transfer of water across the two leafs of cavity walls. 59% of respondents to our question said that EPS beads are suitable for installation in cavity walls in exposed locations. BBA certificates for some EPS materials state that they are suitable for use in exposed locations, provided that necessary precautions are taken (the cavity is not narrow, there are no faults to the masonry or mortar).

As with all loose fill insulates, barriers are required between adjoining buildings and care needs to be taken to ensure holes in the walls are made good to prevent the material leaking out of the wall.

BBA only certifies EPS installations in cavities over 12m high with a height restriction waver, which much be individually assessed by the certificate holder (i.e. material manufacturer) on a site by site basis. Nonetheless 73% of respondents to the survey agreed that EPS beads are suitable for properties that are “too high” – i.e. above 3 stories.

3.2.4 Vermiculite or perlite beads

Perlite and vermiculite insulation are inorganic materials expanded by heat processes that produce white granular material that pours easily into cavities. It settles evenly within a wall as it is free flowing, and supports its own weight. It generally has a thermal conductivity of around $\lambda = 0.045\ Wm^{-1}K^{-1}$. Unlike other insulation materials it must be poured into the top of cavities walls and beneath window openings. This therefore makes it difficult and uncommon to use as a retrofit measure.

The product is relatively uncommon in the UK as a retrofit measure. It is not certified by BBA or covered by CIGA guarantee. It was recommended by very few of our respondents as suitable for any of the wall types listed. One of the trade association respondents said “*I don't know of anyone using perlite or vermiculite these days*”.

Despite the material being moisture resistant there was no information given about the suitability of the material for walls in exposed locations. Only 29% of respondents felt that the material was suitable for these types of walls. Despite the free flowing nature of the product, it is envisaged that it may not be suitable for stone cavities as the pouring process could still lead to unfilled gaps. Only 17% of respondents recommended the product for stone cavities.

3.2.5 Polyurethane foam

Evidence from the literature indicates that polyurethane foam can be injected into walls through a 12mm hole. The compound fluid expands in the wall and hardens to form a foam insulating layer within the cavity. The rigid foam is self-supporting and can be used to support walls where there may be wall tie failures. It can be applied via both the internal and external leaf. It has a lower thermal conductivity than many other insulates typically 0.026 $Wm^{-1}K^{-1}$. There are several BBA Certified Polyurethane foam products on the market and can be CIGA guaranteed. It is generally more expensive than other wall insulates.

Polyurethane foam is moisture resistant and vapour permeable making it suitable for use in high exposure zones. The self-supporting nature of the product means that it should be suitable for use in high rise buildings [note BBA certificates only guarantee for ≤12m]. 60% of respondents to our survey agreed that the product was suitable for use in cavities above 12m high.

The expanding nature of foam makes it suitable for stone constructions as it will expand into areas that other insulates may have difficulty in filling. This reduces the risks of cold spots and thermal bridges. 72% of respondents to the survey agreed that polyurethane foam was a suitable insulate for stone cavity walls.

The Davis Langdon / Inbuilt report stated that polyurethane foam is suitable for narrow cavity walls and partial fill masonry cavity walls. BBA certify polyurethane products for use in walls with cavity widths between 40mm and 200mm; however only a small majority (58%) of respondents affirmed that polyurethane foam was suitable in narrow cavity walls.

Evidence from the literature review suggest that polyurethane foam can be difficult to remove once installed. Therefore if it is installed incorrectly, rectifying any issues caused by the insulation can be very costly. Nonetheless the moisture resistance, vapour permeability and expanding nature of the material makes it one of the most broadly suitable materials available. Furthermore, the lower thermal conductivity should result in better thermal performance of the wall post-insulation.

3.2.6 Urea formaldehyde foam

The literature review indicates that Urea formaldehyde like polyurethane foam can be injected into walls although through a wider 19mm hole. The material hardens to form a foam insulating layer within the cavity. The rigid foam is self-supporting. It can be applied via both internal and external installation. It has a higher thermal conductivity than polyurethane of 0.04 $Wm^{-1}K^{-1}$. There are no BBA certified Urea-formaldehyde insulate. The material is moisture resistant and vapour permeable.

Urea formaldehyde is rarely used in the UK as an insulating material. The literature review indicates that there are a number of health concerns relating to the product that make it unsuitable for usage in certain areas. Particularly: high exposure zones, or areas where the internal leaf of a wall is porous as this can lead to the leeching out of harmful chemicals. As the product ages the foam tends to shrink, this can lead to cold spots and thermal bridging. Most respondents would not recommend urea formaldehyde as an insulation material for most situations.

3.3 Conclusions

Table 5 provides summary a list of the materials we have assumed to be installed in each cavity wall type for estimating the cost and savings from insulation based on this review.

Table 5 – Material assumed suitable for each non-standard cavity wall

Wall type	Insulation type
Standard cavity	Mineral wool
Narrow cavity	EPS beads
Stone cavity	EPS beads
Metal frame	EPS beads
Concrete	EPS beads
Timber frame with uninsulated cavity and uninsulated studwork	EPS beads
Timber frame without a cavity and uninsulated stud work	EPS beads
Partial fill cavity walls	Mineral wool
Standard cavity too high	Weighted (28% Mineral wool 72% PUR)
Home with conservatory	Mineral wool
Home with tiling / cladding	Mineral wool
Mixed wall type	Mineral wool
Exposed walls	PUR
Wall with structural fault	Mineral wool
Wall with finish fault	Mineral wool
Wall with DPC fault	Mineral wool

4 Non-standard cavity walls: quantification methodologies

4.1 Quantifying the number of dwellings

Determining the number of fillable cavity walls was undertaken in five stages as illustrated below in Figure 6. Details of each stage are presented below.

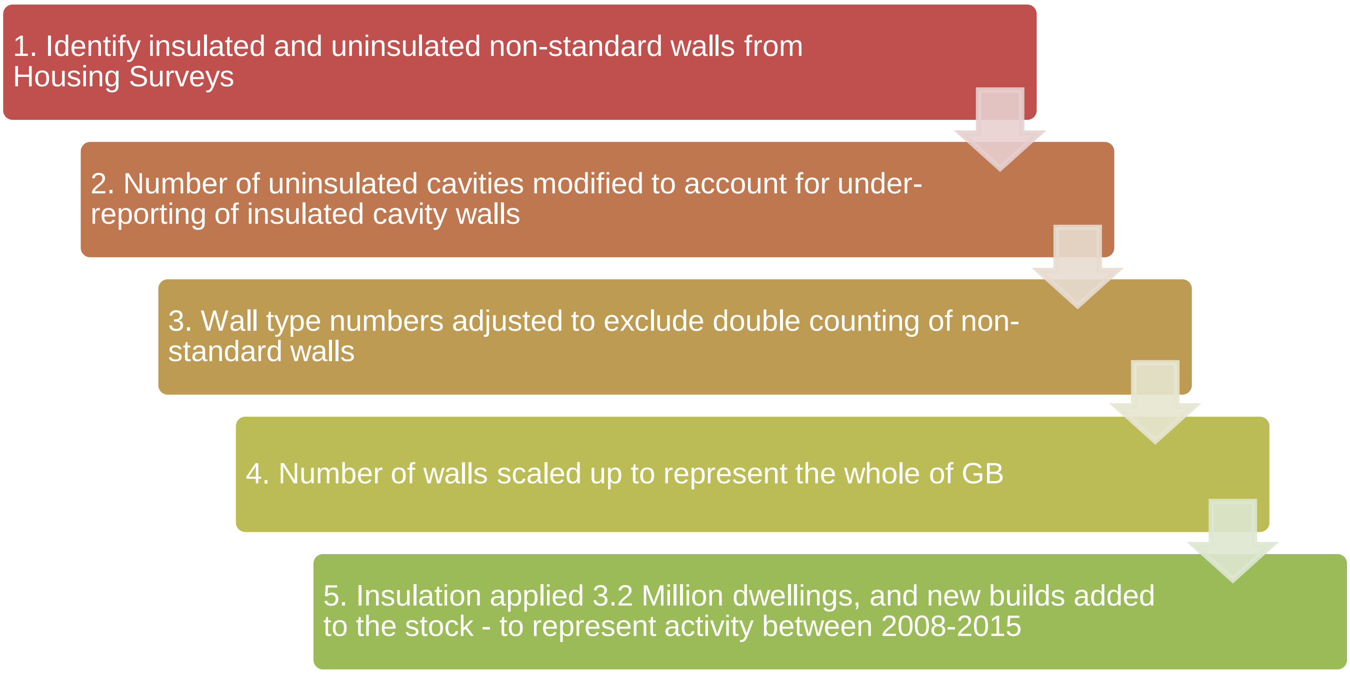

Figure 6 – Process for estimating the number of dwellings with non-standard cavity walls in GB

The EHS is the largest and most comprehensive survey of dwellings in England. The dataset contains records of over 16,000 dwellings in England that are weighted up to be representative of the national stock. In addition there are equivalent surveys in Scotland and Wales (the Scottish House Condition Survey and the Living in Wales survey) which have been included in this analysis. These are referred to in this report as “the housing surveys”. These datasets give some details about wall construction of dwellings, and whether or not homes are insulated – however, the survey does not set out to identify explicitly some of the non-standard walls and lofts that this project aims to identify. To identify dwellings with non-standard walls, we have used combinations of different variables to infer the likelihood that the dwelling surveyed (or that a fraction of the several thousand dwellings the surveyed dwelling is meant to be reprehensive of) is a non-standard cavity walls.

DECC’s Domestic Green Deal and ECO statistics methodology note[8] states that that the EHS is likely to underestimate the number of dwelling that have cavity wall insulation by 5-10%. This is because when carrying out the survey, there is no borescope procedure to check if a cavity is filled (surveyors only look for visible signs of retrofit insulation taking place). In this analysis to estimate underreporting we have

[8] DECC (2016) Household Energy Efficiency statistics methodology note. Available at: https://www.gov.uk/government/publications/household-energy-efficiency-statistics-methodology-note [accessed June 2016]

used National House-Building Council (NHBC) records of homes built since 1986 without cavity wall insulation. See Table 9 for further details.

Some of the records in the housing surveys have been split to represent more than one type of home. Each record in the housing surveys has a given weighting, which gives the figure for the number of homes the record represents. An instance where records are split is, for example, narrow cavities. It is assumed that for a cavity wall home built between 1900 and 1918, one quarter of this weighting will have narrow cavity walls. To avoid double counting, one quarter of this weighting is removed from any other possible wall type classifications. The order in which this is done is detailed below.

In order to estimate the total remaining fillable walls in Great Britain as of June 2015, the dataset was updated to include records of new builds that had taken place between 2008 and 2015 as well as reducing the number of uninsulated walls by 3.2 million (the amount of walls DECC estimate to have been insulated between March 2008 and June 2015).

4.1.1 Stage 1. Identify insulated and uninsulated non-standard walls from 2008 EHS.

This section details how each of the non-standard wall types have been identified and quantified from the housing surveys. For quantifying many wall types a similar approach has been taken to the former Davis Langdon / Inbuilt research. A list of wall descriptions is given in section 3.1.

Narrow Cavities:

In 2012-13, EHS data was collected to identify whether dwellings had narrow cavities. In all former and subsequent surveys, these dwellings are simply recorded as masonry cavity. The number of dwellings with narrow cavities years other than 2012-2013 EHS has been estimated assuming that the same proportion of masonry cavities is narrow in each age band. See Table 6 below.

Table 6 – Proportion of masonry cavity dwellings with narrow cavities, by age band (source: EHS 2012-13[9])

Dwelling age	Percentage of dwellings with masonry cavities that are narrow
pre 1850	21.1%
1850 to 1899	23.8%
1900 to 1918	24.9%
1919 to 1944	8.4%
1945 to 1964	1.9%
1965 to 1974	1.2%
1975 to 1980	1.0%
1981 to 1990	0.7%
post 1990	1.7%

[9] English Housing Survey

A dwelling is assumed to have an uninsulated narrow cavity if:

- it is recorded as having a masonry cavity wall
- it is recorded as being uninsulated
- a proportion of these is then assumed to have a narrow cavity according to Table 6 above

Stone wall cavities

The former Davis Langdon / Inbuilt research[10] identified the following local authorities as typically using stone for building construction, based on British Geological Survey data:

Table 7 – Local authorities typically using stone for building construction; (source: Davis Langdon / Inbuilt, 2012)

Amber Valley	East Lindsey	North Wiltshire
Bolsover	Erewash	Poole
Boston	Forest of Dean	Purbeck
Bournemouth	Gloucester	Richmondshire
Bradford	Harrogate	Salisbury
Calderdale	High Peak	South Derbyshire
Cheltenham	Kennet	South Holland
Chesterfield	Kirklees	South Kesteven
Christchurch	Leeds	Stroud
Cotswold	Lincoln	Swindon
Craven	North Dorset	Tewkesbury
Derbyshire Dales	North East Derbyshire	Wakefield
East Dorset	North Kesteven	West Dorset
West Lindsey		

The only geographical identifier in the EHS is government office region. Therefore, to estimate the number of stone cavity wall dwellings, the proportion of dwellings from the local authorities identified in Table 7 in each government office region was calculated based on DCLG data[11].

[10] Thompson, R., Iwaszkiewicz, C. (2012) Review of the number of cavity walls in Great Britain: Methodology. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48433/5620-review-of-the-number-of-cavity-walls-in-great-brit.pdf; [accessed Dec 2015]

[11] DCLG (2015) Live tables on dwelling stock (including vacants). Available at: https://www.gov.uk/government/statistical-data-sets/live-tables-on-dwelling-stock-including-vacants; [accessed Nov 2015]

Table 8 – Proportion of dwellings from local authorities that generally use stone for construction, by Government Office Region; (source: EHS 2008)

Region	% of stock made up by Local Authority
Yorkshire and the Humber	46.8%
South West	34.2%
East Midlands	34.0%
East	0.0%
London	0.0%
North East	0.0%
North West	0.0%
South East	0.0%
West Midlands	0.0%

A proportion of dwellings in each of the government regions identified in Table 8 above were identified in the EHS as having uninsulated stone cavity walls if:

- The dwelling is in either a rural or sub-urban area
- The dwelling is identified as masonry construction
- The dwelling is built before 1990
- The dwelling is not identified as being insulated
- The dwelling is not a flat

It is assumed that stone cavity walls are not prevalent in the Welsh housing stock. All dwellings in the Scottish Housing Survey identify the construction material of the walls. In Scotland it is assumed that walls are stone cavities if:

- The dwelling has cavity walls
- The wall material is recorded as sandstone or granite.

Metal frame construction

Dwellings were identified as being uninsulated metal frames when:

- The construction type was given as metal frame
- The dwelling was built before 1990
- It was not identified as having been insulated

Concrete construction

Concrete construction dwellings with potentially fillable cavity walls have been identified as follows:

- Having a concrete boxwall, precast frame

- Having in-situ concrete walls with masonry pointing
- The dwelling was built before 1990
- It was not identified as having been insulated

Timber frame cavity walls with fillable studwork

Timber frame construction dwellings with cavity walls and fillable studwork have been identified as follows

- Having a timber frame construction
- Not identified as having internal insulation
- Identified as being built before 1980
- Identified as having masonry pointing (this implies it has a masonry outer leaf)

Timber frame non-cavity walls with fillable studwork

Timber frame construction dwellings without cavity walls but fillable studwork have been identified as follows

- Having a timber frame construction
- Not identified as having internal insulation
- Identified as being built before 1980
- Not identified as having masonry pointing

Partial Fill Cavities

The housing surveys in the UK have little useful data that can be used to identify partial fill cavity walls. NHBC data on partial fill cavities built post 1983 suggests that 29% of traditional build homes that were constructed after 1990 and would not show signs of cavity wall insulation are partial fill. In the housing survey, when a:

- Dwelling is built after 1990
- Is identified as a masonry cavity construction
- Is identified as having an uninsulated cavity

A proportion of these are then assumed to be partial fill based on NHBC data according to their age band:

- 4.8% of homes built between 1991-95
- 37.15% of homes built between 1996-02
- 40.81% of traditional homes built after 2002

Standard cavities with issues

Several issues have been identified in the former research that may increase the cost of insulating standard cavity walls. These are:

- Walls which are too high (above three storeys)

- Walls with conservatories (this causes access issues)
- Walls with panelling, tiles or weatherboarding (this again impedes access to the cavity).
- Dwelling with mixed wall types
- Walls in high exposure zones (these require careful treatment)
- Walls with structural faults (these should be fixed before insulating)
- Walls with finish faults (these can allow moisture to enter the cavity)
- Walls with faulty damp proof courses (insulation may cause damp problems)
- Walls in flood risk areas (not quantified here – but will require non moisture retaining insulation that is more expensive – e.g. Poly Urethane Foam).

Walls with standard uninsulated masonry cavities but with the following issues have been identified as follows:

- Too high: Having more than three storeys
- Dwelling with a conservatory: Identified as having a conservatory door
- Having panelling or similar finish on the wall exterior: Identified as having more than 10% of either the back or front walls with non-masonry finish
- Dwellings in high exposure zones: Identified as in high exposure category (3 or 4) scaled according to the proportion of homes in high exposure zones in each region.
- Mixed wall types: When 10% of the external wall is not masonry cavity
- Wall structure faults: Identified as having a fault on any wall
- Wall finish faults: Identified as having a finish fault on any wall
- Faulty damp proof course: Identified as having a faulty damp proof course

Party cavity walls with bypass

Evidence of party cavity walls is not recorded in any of the GB housing surveys. A report undertaken by Bridgewater Surveyors in 2013 examined the prevalence of bypass constructions in party walls in traditional pitched roof dwellings in a sample of dwellings owned by City West Housing Trust. The sample size was small (only 253 dwellings) and is not representative of the UK, but gives an indication of this construction type in different age band categories.

The report found that nearly all traditional construction terrace and semi-detached homes built after 1966 had bypass construction party walls (71 out of 75), and over half (34 out of 60)of homes built between 1950 and 1965.

It seems reasonable to assume that bypass party cavity walls became the norm following the introduction of part G to the 1965 Building Regulation when sound insulation was specified (now renamed part E).

In quantifying the number of homes with fillable party cavity walls with a bypass, we assume that 90% of terraced and semi-detached homes built after 1965 have a bypass and are fillable and 50% built between 1945 and 1965. Party cavity walls without a bypass can also be insulated however the saving will not be as great as the convection of heat does not occur to the same extent in these walls.

4.1.2 Stage 2. Number of uninsulated cavities modified to account for under-reporting in the housing survey

It is known that the housing surveys will to a certain degree under report levels of cavity wall insulation. DECC's[12] methodology for estimating the number of fillable cavity walls notes that records from the EHS, and devolved nation equivalent surveys are likely to under estimate the number of filled cavity walls in properties built before 1996 by about 5-10%. This is because surveyors do not undertake borescope assessments of the walls in the EHS and therefore mis-identify homes that have insulation but do not show easily identifiable signs of having been insulated.

In addition to this, DECC estimate that all dwellings built after 1995 have insulated cavity walls (or walls with equivalent thermal performance), whereas many homes in the EHS built after this time are recorded as uninsulated. DECC also assume that all homes built between 1983 and 1995 classified as uninsulated on the housing surveys (1984 – 1991 in Scotland) have limited potential - they have a thermal performance close to current standards and therefore savings from additional insulation would be small.

Records from the 2008 EHS identify the following numbers of dwellings by age-band as being uninsulated.

Table 9 – Number of homes recorded as uninsulated by age band (source: EHS 2008)

Year	All homes (000s)	Recorded as uninsulated cavity walls (000s)	% Uninsulated CW in EHS 2008
Pre 1850	740	63	9%
1850-1899	2,137	203	9%
1900-1918	1,883	311	17%
1919-1944	3,642	1,186	33%
1945-1964	4,363	1,735	40%
1965-1974	3,323	1,569	47%
1975-1980	1,491	797	53%
1981-1990	1,953	994	51%
1991-1995	861	402	47%
1996-2002	1,222	566	46%
Post 2002	625	248	40%
Grand Total	22,239	8,073	36%

[12] DECC (2015) Methodology note accompanying headline and detailed National Statistics releases on the domestic Green Deal, Energy Company Obligation and Home Insulation Levels in Great Britain. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/461235/Methodology_Note_Sept_2015_FINAL.pdf; [accessed Jan 2016]

The assumption that all homes built after 1995 are built with insulation does not match data from the NHBC. The NHBC holds a register for warranty for about 80 per cent of new homes built since 1986. This data is based on returns from NHBC's building inspectors, and although it cannot be guaranteed to be 100 per cent accurate the data shows that of homes built between 1996-2002 11% had uninsulated cavity walls and that 72% of homes built between 1991 and 1995 were built with unfilled cavity walls.

Table 10 – records of buildings constructed since 1986 by wall construction type in Great Britain; (source: NHBC building register 1986-2012)

Year of construction	Other	Timber frame	Full fill and retro fit cavity	Partial	None
1986-90	1%	7%	10%	0%	82%
1991-95	0%	7%	16%	4%	72%
1996-02	0%	8%	30%	22%	7%
2003+	9%	17%	34%	25%	2%

Analysis by Consumer Focus suggests that homes built after 1983 are unlikely to have cavity wall insulation retrofitted as RdSAP assumes these walls to have a U value of 0.6 and therefore not worth insulating. RdSAP is the methodology used for assessing the energy performance of a home and to generate a home's Energy Performance Certificate. However, if RdSAP is under-estimating the U-value of uninsulated cavity walls the savings delivered by insulating these will be higher. DECC has commissioned BRE to study this issue further and a report is due in Spring 2016.

We have modified the housing surveys, to account for underreporting of insulated walls, by adjusting the proportion of post-1983 dwellings recorded as having uninsulated cavity walls. Taking evidence from the NHBC dataset we have adjusted the number of uninsulated homes to match the proportion recorded as uninsulated as per the figures given in the NHBC dataset – see Table 10. For example we assume that of all homes built between 1991 and 1995 recorded as uninsulated in the housing survey, only 72% of this potential are assumed to be uninsulated.

Further information is provided in Appendix 4 about the differences between this analysis and DECC's method for estimating cavity wall insulation levels in Great Britain.

4.1.3 Stage 3. Wall type numbers adjusted to exclude double counting of non-standard walls

Due to the way different categories have been quantified from EHS data, there will be some double counting. Records in the EHS have been split to represent more than one type of home. For instance, it is assumed that for every record of a home built between 1900-1918 with a masonry cavity that a quarter (24.9%) will have narrow cavities.

To prevent records being counted in more than one category, a hierarchy has been applied so that if a wall falls under more than one classification, it is included in the category further up the hierarchy and removed from the category further down the hierarchy. This may lead to estimates of the numbers of walls in categories further down the hierarchy being underestimated.

The hierarchy in which walls are calculated is shown below in Figure 7.

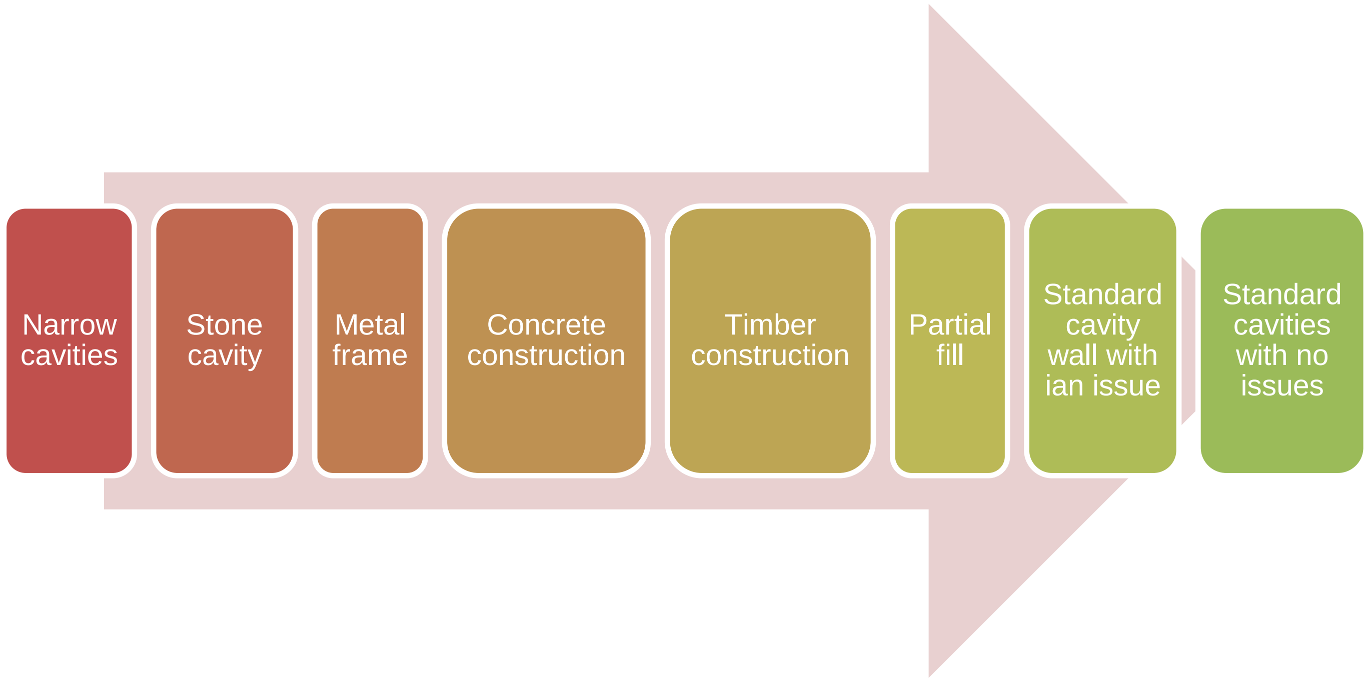

Figure 7 – Hierarchy of cavity wall classifications

4.1.4 Stage 4. Number of walls scaled up to represent the whole of GB

The EHS, LiW and SHCS combined estimate that in 2008 there were 25,837,404 non-residential dwellings. The total number of dwelling in Great Britain in 2008 was estimated to be 26,181,000 according to ONS[13]. To reweight the data set, all records were scaled up by 1.013298 to be representative of all of GB.

4.1.5 Stage 5. Insulation applied 3.2 million dwellings, and new builds added to the stock - to represent activity between 2008-2015

To estimate the total remaining fillable walls in Great Britain as of June 2015, the dataset was updated to include records of new builds that had taken place between 2008 and 2015 as well as reducing the number of uninsulated walls by 3.2 million (the amount of walls DECC estimate to have been insulated between March 2008 and June 2015).

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[13] ONS (2010) Regional Trends: Housing. Available at: http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-254270; [accessed Jan 2016]

4.2 Quantifying the potential carbon saving

All carbon savings have been calculated using SAP 2012. National savings modelled from savings calculated for archetype properties. These archetypes are formed from 9 types of building and 4 different fuels. The archetypes modelled had the following characteristics:

Table 11 – Dwelling characteristics of archetypes used for modelling carbon savings

Dwelling Type	Floor area (m^2)	% double glazed	Roof U-value
Bungalow detached	67.3	94%	0.32
House detached	148.6	89%	0.34
End Terraced House	78.8	90%	0.37
Ground floor flat	60.9	81%	0.00
Mid floor flat	60.9	81%	0.00
Terraced house	78.8	87%	0.42
Semi-detached bungalow	63.5	94%	0.34
Semi-detached house	88.8	92%	0.34
Top floor flat	60.9	81%	0.58

The average saving for each building type was calculated by generating a fuel weighted saving. These weighted savings were multiplied up by the total number of dwellings of each building type that had the potential to have insulation installed.

The U-values for each wall type before and after insulation are given in the following table:

Table 12 - U-Values of wall types, pre and post insulation

Wall type	U value before insulation	U value after insulation	U value difference
Standard cavity	1.600	0.500	1.1
Narrow cavity	1.693	0.666	1.027
Stone cavity	1.083	0.855	0.228
Metal frame	1.427	0.596	0.831
Concrete construction	1.427	0.596	0.831
Timber frame with uninsulated cavity and uninsulated studwork	1.129	0.311	0.818
Timber frame without a cavity and uninsulated stud work	1.129	0.383	0.746
Partial fill cavity walls	0.464	0.360	0.104

To compensate for difference between *in-situ* savings and modelled savings (arising from comfort taking and model short-falls), a 50% correction factor has been applied. This comprises of a 35% in-use factor as specified for calculating savings for cavity wall insulation under the Green Deal[14] and a 15% comfort factor[15].

4.2.1 Modelling CO_2 saving party cavity walls with bypass

For the purpose of modelling the CO_2 savings from insulating Party Wall insulation, we will assume a U-value of 0.5 $W\ m^{-2}\ K^{-1}$ for an uninsulated wall and an insulated value of 0.2 $W\ m^{-2}\ K^{-1}$ as recommended in RdSAP 2012. A 15% *in-situ* reduction factor will also be applied as per the Green Deal and ECO Measures Update 2014[16]. For this calculation it is assumed that the U-value of external walls is 0.6 $W\ m^{-2}\ K^{-1}$. This is the assumed "as built" U-value for cavity walls built between 1983 and 1990 in England and Wales, and midway between the assumed U-value of the value for "as built" cavity walls built 1967-1965 (1.00 $W\ m^{-2}\ K^{-1}$) and for homes built after 2012 (0.28 $W\ m^{-2}\ K^{-1}$).

4.3 Quantifying the potential cost

The data has been used to estimate the cost of treating each non-standard wall type. Costs were gathered from surveys of industry experts. For each wall category, the cheapest material that is appropriate for each wall type has been used.

[14] DECC (2012) How the Green Deal will reflect the in-situ performance of energy efficiency measures. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/383547/5505-how-the-green-deal-will-reflect-the-insitu-perfor.pdf; [accessed Jan 2016]

[15] Sanders, C., Phillipson, M., (2008), An Analysis of the Difference between Measured and Predicted Energy Savings when Houses are Insulated. Available at: http://web.byv.kth.se/bphys/copenhagen/pdf/089-2.pdf; [accessed Jan 2016]

[16] DECC (2014), Green Deal and ECO Measures Update 2014. Available at: https://www.gov.uk/government/publications/information-for-the-supply-chain-on-green-deal-measures; [accessed Feb 2016]

Table 13 - 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

4.3.1 Costs for insulating party cavity walls with bypass

- £3 per m^2 for installers (inc all costs & margin) and,
- about £2.50 per m^2 for material.

Provided by Knauf (overall cost of £300-£350 per wall)

5 Non-standard lofts: identification and treatment

5.1 Classification of non-standard lofts

The stakeholder survey raised a large number of factors which would potentially make a dwelling less cost effective to insulate – either by reducing the carbon saved or by generating additional installation cost. These broadly fall across three categories: variations in roof and loft construction; remedial and access issues which cause a barrier to taking action; and external features including roof covering.

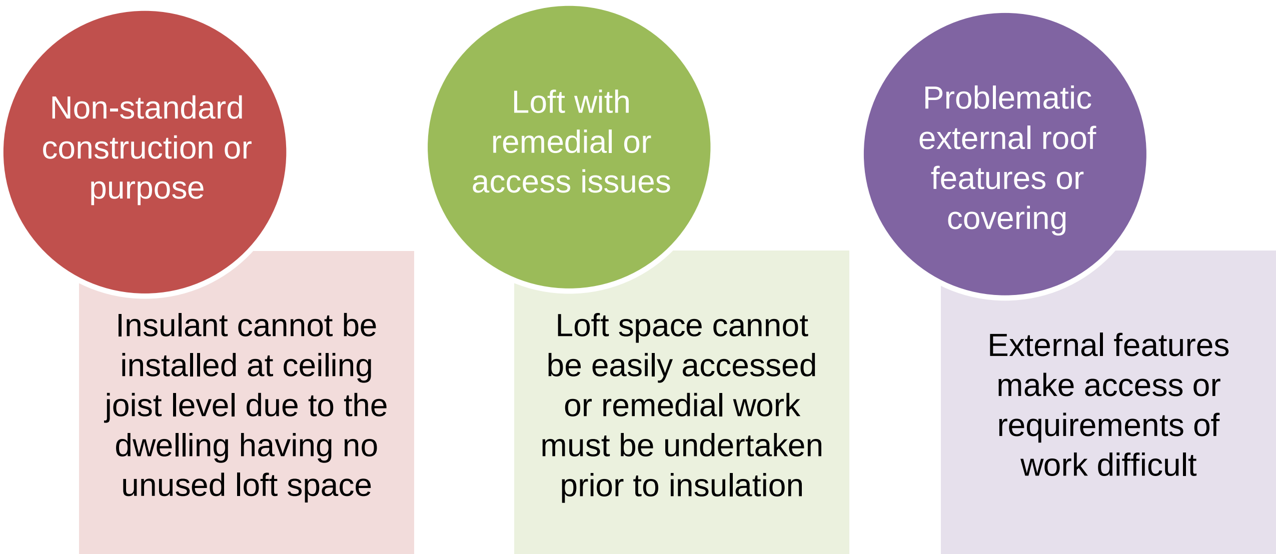

Figure 8 – Defining "non-standard" loft categorisations

Table 14 summarises issues identified through the stakeholder survey and desk-based research, which may lead to increased work or cost when seeking to insulate the loft of a dwelling. In this section, we describe those in more detail which we have been able to quantify in this report.

Table 14 - Challenges to improving the thermal performance of a loft / roof cost-effectively

Construction / purpose	Remedial / access	External features / covering
Flat roof Room-in-roof (conversion) Room-in-roof (as built) Mansard roof Chalet roof Mixed roof construction Roofs with dormer windows Dutch Gable / Gablet, Gambrel, Dutch, Butterfly, Barrel Vault, Groin, Domed, Gullwing Mobile home / park home	Structural defect (sagging / humping/spreading) Unknown level of existing insulate Existing defective insulate Existing asbestos insulation Infestation (rodent, woodworm, wasp) Access / obstructions Loft clearance required Internal condensation issue Inadequate ventilation	Thatched roof Green roof Glazed roof Inadequate roof underlay (rain barrier) Degraded / faulty waterproofing Masonry / tile fault Detailing between sections Parapet walls Overhanging eaves

5.1.1 Loft construction and purpose

Flat roofs: whilst a conventional roof construction, flat roof dwellings are considered “non-standard” due to the higher cost of improving insulation. Post-construction, it can be difficult to assess the depth and type of insulant applied to a roof structure. Approaches to manage condensation risk, including the insulation type and ventilation, are particularly important for flat roof dwellings due to the risk of air rising into the roof structure (see Section 5.2.2). Often areas of flat roof make up part of a mixed roof on a dwelling, particularly for extensions (see below comment on mixed roofs).

Room-in-roof dwellings: this includes dwellings that are constructed with a habitable space in the roof (chalet, mansard, pitched room-in-roof) and dwellings that have received a loft conversion post-construction. Applying insulating to these properties is challenging for a number of reasons, and is likely to require a dwelling-by-dwelling specification due to a variety of conversion types and uses.

Sarking insulation (placed above and between the rafters to create a warm roof structure, see

Table 16) is particularly suitable for room-in-roof dwellings as it reduces the need for ventilation of the roof structure and maximises head height in the internal room. However, lifting and replacing the roof covering is likely to be a prohibitive cost unless this is already due to take place.

Achieving a reasonable U value may require the roof structure to be deepened resulting in a loss of head height – typically expected to be at least 2.1 metres. Building Regulations do identify this as a factor which may result in the compromise of target U values. Inversely the depth of insulation may also be important for external flat roof solutions. In order to achieve target U values, increased depth from systems such as vacuum insulation panels may interfere with external services (e.g. solar panels, aerials) or require flashing to be heightened. Some insulation materials, for example using Aerogel, have a high thermal resistance and so can provide equivalent performance at reduced thickness; however these are more expensive.

Mixed roof types: many dwellings have mixed-construction type, particularly where there have been flat roof extensions, and this can introduce challenges. Ensuring insulation and vapour control continuity at the junction between the steeper lower section of a mansard roof and the shallower upper pitch may be challenging.

Continuity between the roofs of adjoining terraced and semi-detached properties may also prove difficult, particularly if insulation placed above rafter-level increases the height of the roof structure. This may require additional lead flashing to ensure water-tightness, and potentially planning permission. Funding work for more than one roof type may also prove challenging, as funding assumes one roof type and one contractor – which may result in incomplete jobs.

5.1.2 Remedial & access issues

Access / obstructions: access, and obstruction from internal services, may prove a challenge to reaching areas of the loft to apply insulation. Dwellings may lack a loft hatch/opening for access to the roof space, or ceiling joists may be boarded over.

In attic room constructions and room-in-roof conversions, dwarf walls may block access to the corners leaving a space either fully concealed or used for storage. Behind this dwarf wall is an uninsulated space in which it may not be possible to insulate at rafter or ceiling level without removing boards or the stud wall. Failure to insulate this are of the loft envelope area will result in a thermal bridge. It is recommended (BS5250 Control of Condensation) that insulation and vapour control layers should be fitted all the way down the pitch of the roof (the outermost structure), rather than on dwarf walls and across the ceiling.

Blown loose fill insulation may be an option for hard to access areas, although there are potential risks associated with this approach also. Loose fill insulation can be easily displaced where there is ventilation, and loft spaces may not be contained leading to loss of insulate. Loose fill insulation, which is often comprised of heavier materials, can also cause the ceiling to sag, particularly if wet. When the pitch of the roof is very low, blown roof insulation may not have enough cross-flow ventilation to avoid condensation. If visibility is limited these issues may not be identified, and moreover there is no way of checking or ascertaining that the depth or density of insulant that has been blown in is continuous or adequate. If insulant does become damp and defective, it will require specialist extraction equipment.

This is similarly the case if any changes are made to the roof construction, or the property is demolished, to avoid loose insulate polluting the surrounding environment.

Existing defective insulation material / infestation: there are a number of issues which may result in the need to remove insulation or other material prior to improvement work taking place. This includes the need to remove asbestos containing materials when refurbishing roof elements; dealing with infestation or vermin (e.g. rodents, woodworm, wasp nests etc.), as well as protected species (e.g. bats); and removing defective (e.g. damp or damaged) insulation material.

Condensation risk: **Inadequate ventilation / condensation risk:** ventilation of loft and roof spaces is a crucial consideration when installing insulation on any element. The type of existing construction needs to be considered, since ventilation and exposure can vary substantially, particularly in older properties. There is risk of condensation within all roof spaces and structures which are on the cold side of the insulation layer and where there is thermal bridging.

For all types of roofs, it is important that adequate ventilation is ensured for roof joists and structures in order to minimise the risk of condensation[17]. External weatherproofing on flat roofs is not usually vapour permeable, which introduces the risk of interstitial condensation from rising warm moist internal air. A condensation risk analysis should be undertaken to ascertain the appropriate position of the vapour control layer.

Loose fill insulates, and even quilted insulates, can be easily blown by air movement around roof spaces. This is particularly the case in older properties where there may be over-ventilation of the roof space through lack of underlay to open ventilation gaps at eaves. This insulate may escape into ventilation pathways, or settle on down-lighters creating a potential fire hazard.

Strength of roof / ceiling structure: where insulation is affixed directly to external roof elements (for example flat roof insulation) this will generate additional load on the structure. If the weight of insulation may add excessive strain, roof structures may require reinforcing or replacing. Some solutions such as vacuum insulated panels may be particularly heavy. For external flat roof installations, the weight of installers and equipment also needs to be considered and relevant equipment (ladders, scaffolding etc.) used if necessary.

Roof structural faults: there are a number of types of roof fault which may need to be rectified in order for a loft to be effectively insulated. Typically these will manifest as unevenness in the roof, caused by sagging, humping or spreading. Defects or rot in supporting structures, or under-sizing of elements, may cause this.

Structural faults may allow water to ingress, causing damp and rot problems within the structure (exacerbating any weakness), and damaging loft insulation and other internal services. Where insulation is affixed to roof structures, for example on flat roof or rafter level insulated dwellings, the ability of the structure to bear the additional weight of this may need to be considered. Any major structural weakness poses a health and safety risk to occupants.

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[17] For an overview of ventilation approaches, see BRE (2002): Thermal insulation avoiding risks.

Structural faults require dwelling-by-dwelling assessment, and the cost of taking either remedial action to strengthen the structure, or replacing part of or the entire roof, are likely to range massively. Where major structural replacement is taking place, there may be the opportunity to more cost effectively insulate flat roofs (via a "warm deck" approach, with insulant above the roof structure), or insulated sarking between and across the top of pitched rafters.

5.1.3 Non-standard roof covering

Inadequate / missing roof underlay: A large number of older properties have no roof underlay, which is a secondary line of defence against windblown rain or snow. These should not be insulated with standard mineral fibre and cellulose materials that are not water-resistant. Where insulation is stapled below the rafters there is a risk of interstitial condensation whereby warm, moist air penetrates this layer and condenses in the roof structure. By creating a perfect seal, some insulants like sprayed polyurethane foam may reduce this risk.

External access: access to flat roofs for external insulation may prove difficult. These tend to be located on side and rear elevations which may have more limited access routes. External services, for example satellite dishes, drainage, terraced areas, may also inhibit accessibility.

Non-standard roof covering: the roof covering may impact the possible approaches for applying insulation. Thatched roofs are treated separately to roofs with a slate or tile covering in SAP 2012. Thatch has a much greater insulating value than other traditional roof coverings and so may not require insulation improvements. An uninsulated thatch roof is assumed in SAP 2012 to have a U-value below the building regulations threshold for requiring additional insulation (0.35 W/m^2K).

The EHS contains information on the type of roof covering of a dwelling; see Table 15. From this we can estimate that there are very few thatched roof dwellings in GB, although this is slightly lower than other estimates[18]. Because of this uncertainty, and the low number of observations available across the GB housing surveys, we have omitted thatched roof as a non-standard loft type in the main quantifications of this report.

The majority of dwellings have a roof covering which will be built around a standard loft structure, and so can be treated as standard.

[18] For example, English Heritage report that there are an estimated 50,000 thatched roof dwellings in Britain. English Heritage (2012): Energy Efficiency and Historic Buildings: Insulating thatched roofs.

Table 15 – Roof covering of dwellings in England, in 2011; source: EHS 2011[19]

Roof covering	Number of dwellings	%
asphalt	582,801	2.6%
clay tile	3,499,364	15.4%
concrete tile	13,225,893	58.1%
felt	392,691	1.7%
glass/metal/laminate	340,584	1.5%
man-made slate	1,308,087	5.7%
mixed types	422,728	1.9%
natural slate/stone/shingle	2,957,502	13.0%
thatch	24,490	0.1%
Total dwellings (EHS)	22,754,140	

Roof covering faults: any gap in the roof covering, caused by slippage, deterioration or damage of external materials introduces routes for water to enter the roof space. Damp is likely to damage the structural and thermal integrity of insulating materials, as well as causing further damage to the dwelling interior. The type of covering fault will depend in particular on the type of material used to cover the roof. For example: asphalt or felt on flat roofs can crack and blister; tiles can crack or slip; and all roof materials will degrade over time. It is common for the nails which fix slates to the roof deck to corrode over time, known as “nail sickness”, causing slates to loosen and potentially fall.

The work required to resolve a fault in the roof covering of a dwelling will vary substantially depending on the specific issue. As with roof structural replacement, where extensive renewal of roof covering is taking place there may be an opportunity to cost effectively undertake measures that may be otherwise prohibitively expensive.

5.2 Insulating non-standard lofts

5.2.1 Pitched roofs

Pitched roofs comprise a wide range of construction forms. In terms of the application of insulation, the main distinguishing characteristic is whether the insulation is to be installed at rafter level, creating a warm loft space, or at ceiling level, creating a cold loft space. This will be determined by whether the roof space requires heating i.e. in cases where the attic space is part of the original design, as in a chalet or mansard roof (or other roof construction with habitable rooms in the roof space), or in a room-in-roof

[19] This is the most recent housing survey for which “thatch” was recorded as a separate roof covering category. In the most recent EHS datasets they are grouped with “natural slate/stone/shingle”. No thatched roofs were recorded as part of the 2008 LiW or SHCS surveys.

conversion. It is conventional for insulation to be rolled between and across joists at ceiling level, and in this report we term this a “standard” installation.

Figure 9 shows in cross-section the basic elements of a pitched roof construction. A typical retrofit for a loft of this type would be to roll insulate between the joists at the ceiling level of the property, thus creating a cold unheated loft space. However, it is also common for loft spaces to be converted into heated living areas, necessitating insulation at rafter level to create a warm attic space (Figure 10. There are also a number of roof constructions with as-built attic spaces which may be uninsulated, for example mansard (Figure 11) or chalet roofs (Figure 12).

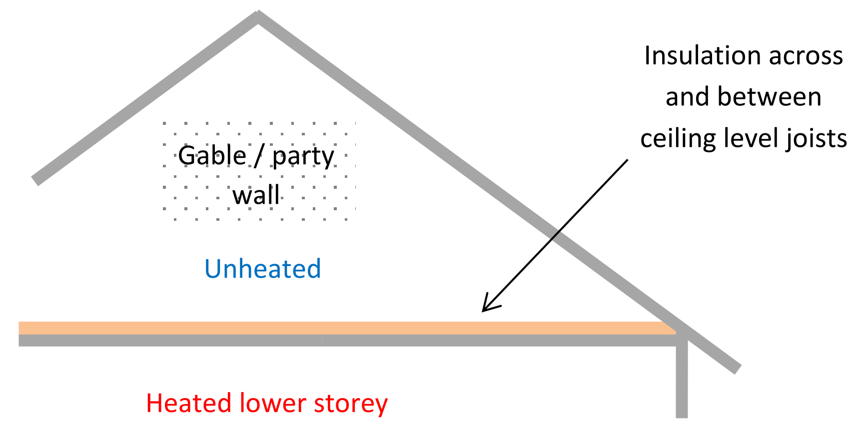

Figure 9 – Cross-section showing basic elements of pitched roof construction with standard insulation

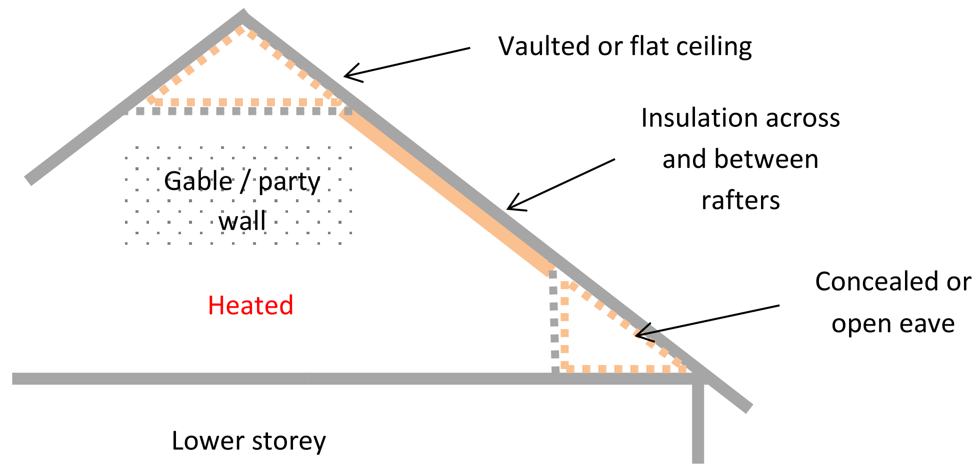

Figure 10 – Cross-section showing basic elements of converted room-in-roof with rafter-level insulation

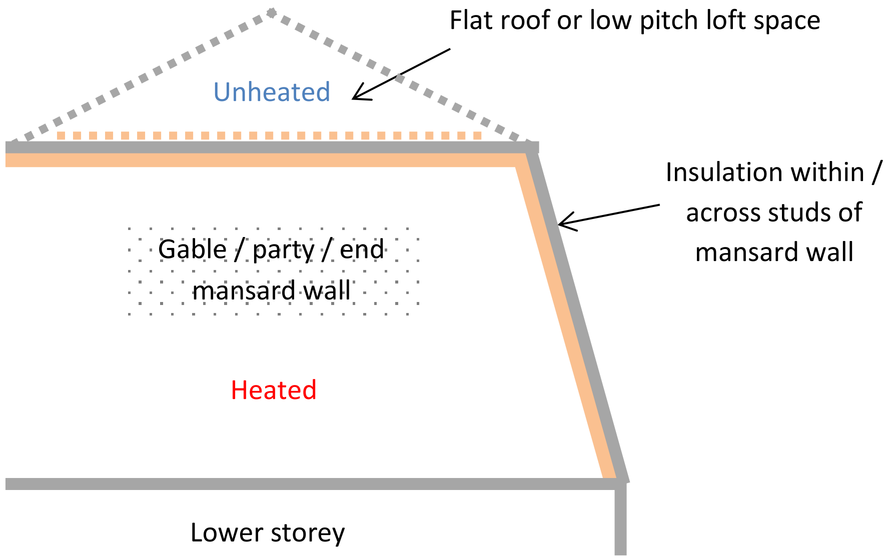

Figure 11 – Cross-section showing basic elements of mansard roof construction with insulation

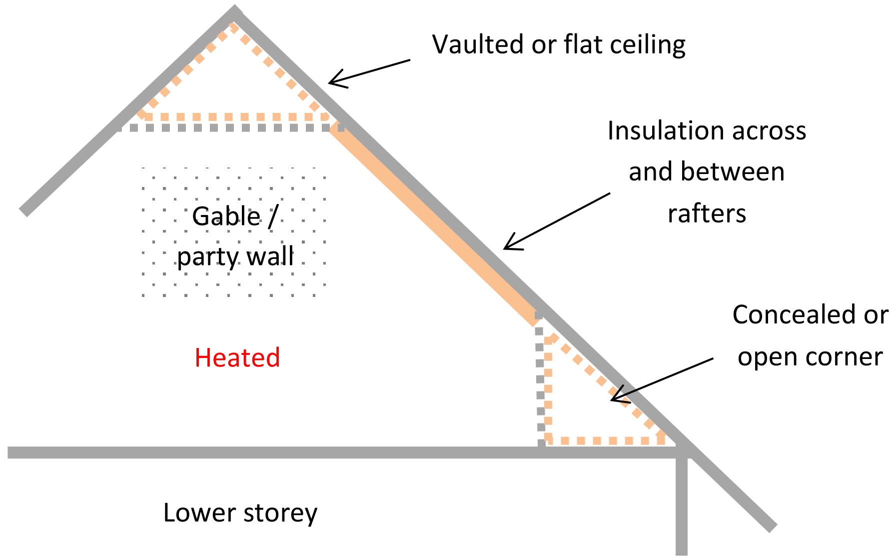

Figure 12 – Cross-section showing basic elements of chalet roof construction with insulation

Table 16 summarises solutions for insulating the identified typical elements of pitched roof constructions, along with the key considerations in the selection of an appropriate solution. These were identified by respondents to the stakeholder survey, supported by research of secondary sources.

Table 16 – Summary of approaches to insulating pitched roof elements

Accessible horizontal loft areas	
Solution:	Insulate between and across lateral wooden joists, above ceiling to heated living area
Materials:	- Mineral wool blanket (glass wool, rock wool) - Natural wool blanket (sheep wool, cellulose wool) - Blown loose fill glass wool or rock wool - High-density slabs of mineral wool - Sprayed foam insulation (polyurethane)
Considerations:	- Storage - Location of services - Use of unheated loft space - Ventilation - Weight of loose insulate - Fire risk from proximity to lights / electrics - Cold bridging (rafters)[20]
Difficult to reach loft areas	
Solution:	Depending on access, blow loose fill insulation or roll insulate at ceiling level
Materials:	- Blown loose fill glass wool or rock wool - Mineral/natural wool blanket - Sprayed foam insulation (polyurethane)
Considerations:	- Ventilation - Migration of loose insulate - Maintaining ventilation pathways (e.g. eaves guards) - Weight of loose insulate - Fire risk from proximity to lights / electrics - Removal of boards for access - Storage - Location of services - Depth and density of insulant - Removal of insulant
Sloping pitched roof elements	
Solution:	Insulate between and beneath wooden rafters – cold roof structure
Materials:	- Multi-layer foil - High-density slabs of mineral wool - Rigid insulating board - Insulated plasterboard lining - Flexible insulated lining

[20] It is recommended as more thermally efficient to lay the insulation as a series of layers – between the rafters and then across the rafters to reduce thermal bridging. BRE (2002): Thermal insulation avoiding risks.

	- Sprayed foam insulation (polyurethane) - Aerogel
Considerations:	- Strength of existing ceiling - Required head height - Redecoration - Required finish - Condensation (interstitial) - Ventilation - Cold bridging (rafters)[21] - Securing insulate
Solution:	Insulate between and laid across the topside of rafters (sarking) – warm roof structure
Materials:	- Multi-layer foil - Rigid insulating board
Considerations:	- Ventilation - Access - Cold bridging (rafters)[22] - Reducing heat loss through gaps between insulation and roof layers - Interstitial condensation - Securing insulate between rafters - Lifting and replacing roof tiles and battens - Impact of increased depth on guttering, fascia and soffit details - Intersection between roofs of adjoining properties - Weatherproofing - External appearance, particularly heritage buildings
Dwarf walls/vertical elements	
Solution:	Insulation applied directly to wall area
Materials:	- Rigid insulating board (polyurethane, polystyrene foam, phenolic foam) - High-density slabs of mineral wool - Insulated plasterboard lining - Flexible insulated lining - Aerogel
Considerations:	- Thermal bridging - Storage - Securing insulate

[21] BRE (2002), as above.
[22] BRE (2002), as above.

5.2.2 Flat roofs

Flat roof elements are found on many different types of roof construction, including small areas such as the ceiling of dormer windows, and often as part of extensions to dwellings with other roof types. Table 17 summarises the solutions for insulating flat roof areas, and considerations that need to be taken into account.

There are two main approaches to insulating flat roofs – to place insulate above the roof structure ("warm deck") or to place insulation below the roof structure ("cold deck"). It is important to note that**,** the BRE (2002) technical guidance document "Thermal insulation: avoiding risks" advises that "cold deck" insulation is a poor option in the UK, due to the high risk of condensation caused when humid air entering from inside or outside the building is not adequately ventilated away. The preferred approach where possible is to insulate or convert to a warm deck roof.

A further solution identified in the survey, but not included in the table, would be to construct a new low pitched roof, or a cavity with a new roof above or ceiling below, and insulate this with mineral wool or other standard insulate.

Table 17 – Summary of approaches to insulating flat roof elements

Flat roof areas	
Solution:	Internal roof insulation (insulate below roof structure, "cold roof")
Materials:	- Insulated plasterboard lining - Flexible insulated lining - Rigid insulating board (polyurethane, polystyrene foam, phenolic foam) - Sprayed polyurethane insulate
Considerations:	- Head height - Ventilation - High risk of condensation - Strength of roof structure - Internal services - Asbestos containing materials (ACMs) - Existing damp material
Solution:	External insulation (insulate above roof structure, "warm roof"), either - insulation under weatherproof cover - insulation above weatherproof cover ("inverted roof")
Materials:	- Rigid insulating boards, with weatherproof cover - Inverted roof where insulation is over the weatherproof cover - Sprayed polyurethane insulate - Vacuum insulated panels
Considerations:	- Weatherproofing - Ventilation - Strength of roof structure - External services - Access

	- Flashing and detailing - Roof finish - Rainwater drainage - External appearance, particularly heritage buildings
Solution:	Blow insulation into flat roof void (if there is one)
Materials:	- Blown loose fill glass wool or rock wool - Sprayed foam insulation (polyurethane)
Considerations:	- Cost (cheaper) - Existing damp material - Ventilation - Migration of loose insulate

6 Non-standard lofts: quantification methodologies

6.1 Quantifying the number of dwellings

In order to estimate the number of domestic properties with loft insulation, DECC[23] use the 2008 housing survey data as a baseline and then adjust this forward to the present, by subtracting known installations undertaken under Government schemes and adjusting for new build homes. Benefits of this approach are that:

- It sets a standard baseline for England, Scotland and Wales; since this is the most recent year for which housing survey data is available for all of three devolved areas.
- It enables detailed data on installs under Government schemes to be used; this more accurately quantifies the exact number installed over this time period than the inherent variation in the sampling of the EHS survey.

Based on the housing survey data, properties are allocated to one of four loft insulation categories:

1. "insulated": recorded as having >125mm loft insulation.
2. "easy to treat": recorded as having <125mm loft insulation, but not identified as "hard to treat".
3. "hard to treat": lofts which are hard to insulate, including those with flat roof, roof with a very shallow/inaccessible pitch, and properties with a room-in-roof.
4. "no loft": recorded as having no loft.

Each quarter, the number of known loft insulation installations delivered under Government schemes[24] are added to the "insulated category" and the equivalent number subtracted from the "easy to treat" category. It is assumed that no "hard to treat" lofts have been insulated through these schemes. New builds figures are split between the "insulated"[25] and the "no loft"[26] categories.

Applying a slightly different categorisation to the same data, in their 2013 EHS report[27], DCLG differentiate four categorisations of dwelling according to their ease of installing or topping up for loft insulation – non-problematic (easy to treat), and more problematic (loft full boarded across joists leading to extra work and expense), room-in-roof, and flat or shallow pitched roof (all hard to treat).

[23] DECC (2013): Domestic Green Deal and ECO statistics methodology note. Available at: https://www.gov.uk/government/publications/domestic-green-deal-and-eco-statistics-methodology-note; [accessed Jan 2016]
[24] This includes: CERT; Warm Front; CESP; Green Deal; and ECO.
[25] Building regulations require new builds to have 270mm loft insulation (or equivalent) as standard.
[26] Assumed from analysis of EHS that 60% of flats do not have a loft; all houses assumed to have a loft.
[27] See Chapter 3: Hard to treat and energy inefficient properties; Department for Communities and local Government (2015). Available at: https://www.gov.uk/government/statistics/english-housing-survey-2013-energy-efficiency-of-english-housing-report; [accessed Jan 2016]

The methodology used to derive the estimates presented in this report is described in detail in the following sections. Whilst this is largely consistent with the DECC methodology described above, it differs in the following ways:

- Installations of insulation in non-standard lofts, recorded under Green Deal/ECO are accounted for. One of the major assumptions made in the insulation estimates methodology is that no “hard-to-treat” lofts were insulated under Government schemes between 2008 and 2015. Whilst this was the case under CERT, Warm Front and CESP, flat roof insulation, room in roof insulation and loft insulation at rafter level have been eligible measures for ECO obligations, and eligible for Green Deal finance.
- Non-standard lofts are differentiated by a number of types rather than being grouped as in the DECC published statistics. This enables us to provide a more representative assessment of cost and carbon savings, as these can be tailored more closely to the requirements of each of these dwelling types.
- This includes a quantification of lofts which are hard to access; similar to the “more problematic” type described above.

Determining the remaining potential for treating non-standard lofts was undertaken in four stages as illustrated below in Figure 13. Details of each stage are presented in this section.

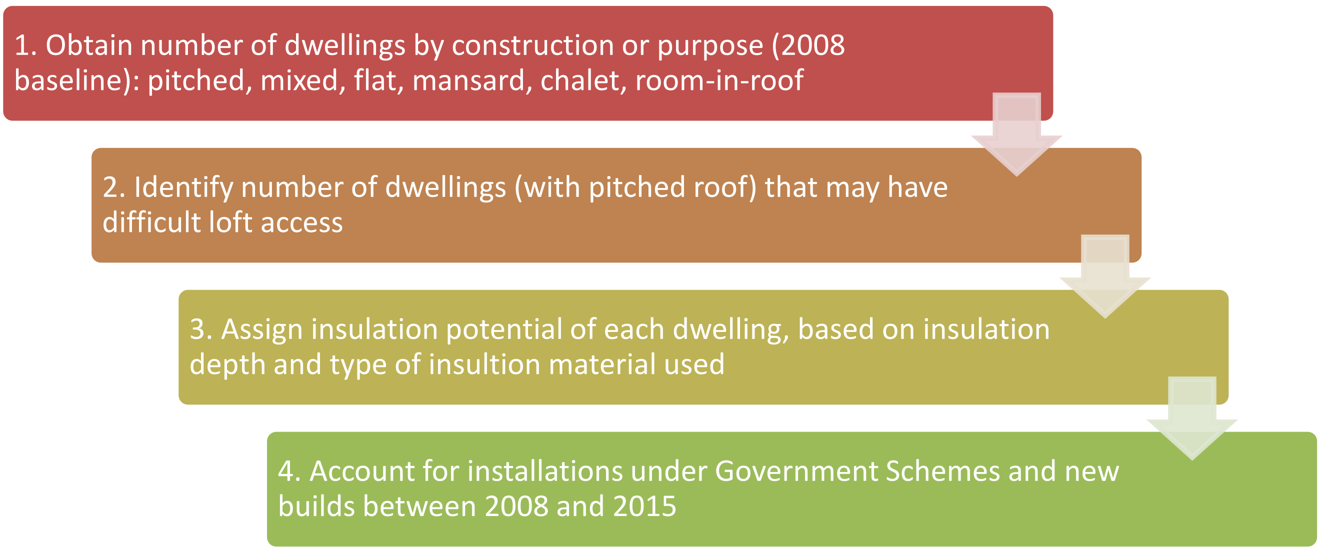

Figure 13 – Process for estimating the number of dwellings with non-standard lofts in GB

6.1.1 Stage 1: Obtain number of dwellings by construction or purpose

Each of the 2008 sub-national housing stock survey datasets record whether a dwelling has an exposed roof or loft (or does not, for example in the case of the ground floor dwelling of a block of flats), some details on the roof construction of the dwelling (including the type and extent), as well as whether the loft is used as a habitable room.

Analysis was undertaken across the housing surveys to derive a standard classification of dwellings across 7 categories, based on their construction. These are summarised in Table 18. Four standard roof constructions can be identified: pitched roof, flat roof, mansard roof, and chalet roof.

Mixed roof types are also identifiable where front and rear elevations of assessed properties are of different construction. A roof type is considered primary if it covers greater than 50% of the extent of the roof area; mixed if recorded as a 50:50 split between two types.

The EHS and LiW surveys record where a room-in-roof conversion has taken place in a dwelling. Whilst the SHCS does not record this, it can be identified where a dwelling has at least one habitable room in the roof space which is taken as an indication of a room-in-roof (either converted or as-built). Mansard and chalet roof dwellings, whilst containing habitable spaces within the roof, are quantified separately in this report and considered "as-built" rather than "conversions".

Table 18 – Derivation of roof categories from housing stock surveys

Roof construction	Details on derivation from housing surveys
No roof / loft	Dwelling recorded as having no loft (EHS, SHCS, LiW)
Mixed roof	Dwelling in which no single roof construction type extends across greater than 50% of the roof area (combining front and rear elevations)
Room-in-roof	Dwelling recorded as having a pitched roof (*defined as below*) **AND** recorded as having a room-in-roof conversion (EHS, LiW) **OR** recorded as having habitable rooms in the roof (SHCS)
Pitched roof	Dwelling recorded as having a pitched roof covering >50% of the roof area (EHS, LiW); includes dwellings with mono pitch roof (SHCS) **AND** not recorded as room-in-roof
Flat roof	Dwelling recorded as having a flat roof covering >50% of the roof area (EHS, SHCS, LiW)
Mansard roof	Dwelling recorded as having a mansard roof covering >50% of the roof area (EHS, LiW); includes dwellings with half mansard roof (SHCS)
Chalet roof	Dwelling recorded as having a chalet roof covering >50% of the roof area (EHS, SHCS, LiW)

6.1.2 Stage 2: Identify number of dwellings that may have difficult loft access

The number of pitched roof dwellings that are likely to have accessibility problems are also quantified and subtracted from the number of standard pitched dwellings.

No single variable is recorded across all of the housing surveys which captures this in the same way, however information is recorded which can be used to give an indication of how frequently loft access issues are likely to be encountered in dwellings. In the EHS and LiW 2008 surveys it is recorded where the loft of a dwelling is boarded over[28]. This is the variable used to characterise "more problematic" dwellings by DCLG[29]. In the SHCS 2008 survey it is recorded whether a dwelling has a loft hatch.

6.1.3 Stage 3: Assign insulation potential of each dwelling

In order to distinguish lofts with remaining insulation potential, we consider information on insulation type and depth from the housing survey datasets.

Each of the housing surveys contain information on whether insulation is present, the type of insulation, and the thickness of this – although it should be considered how this information is identified. These variables may be derived in three ways:

- **Physical inspection and measurement** – by a technical surveyor visiting the property who is able to access the loft, and identify and measure any insulation present.
- **Occupant description –** where the surveyor cannot access the loft, the householder can provide information on whether it is insulated based on their knowledge from living in the property.
- **Imputation based on known characteristics of dwelling –** there are also cases where neither of the above is possible, for example due to the property having a flat roof. In this case visibility of insulation material and depth is obscured and it is likely that this was installed during construction of the building and so details unknown to residents. For these dwellings, the housing survey contains an imputed value based on the age of construction in conjunction with building regulations.

Overall, the percentage of physically surveyed lofts in the 2008 housing surveys is around 54%[30]. This is particularly low for flat roof properties for which physical inspection is difficult, and so flat roof insulation estimates carry a substantial degree of uncertainty.

The insulation estimates for non-standard lofts should therefore be treated with some caution. Because of this we have presented quantified estimates in this report not just for the remaining uninsulated non-standard dwellings, but also for the total number of dwellings of this categorisation, as there is the possibility that loft insulation rates are overestimated for non-standard dwellings.

Information on the presence and depth of information is used in combination with the recorded type of loft insulation. For the EHS and LiW, four types of insulant material are recorded – mineral wool, rigid foam board, high performance quilt, and vermiculite beads. Insulation material is not recorded in the SHCS 2008 so this is assumed to be mineral wool.

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[28] "Fully" boarded is where at least 90% of an area with height >1m is boarded over.

[29] See Chapter 3: Hard to treat and energy inefficient properties; Department for Communities and local Government (2015). Available at: https://www.gov.uk/government/statistics/english-housing-survey-2013-energy-efficiency-of-english-housing-report; [accessed Jan 2016]

[30] This is a combination of physical inspections from EHS and LiW, and properties receiving full surveys in the SHCS.

Information on the typical thermal performance of these materials is used to assign a threshold depth above which the loft of a dwelling is considered to be insulated. There is a strong 'diminishing returns' effect with savings from loft insulation, which means that even where properties fall well short of the required depth to achieve building regulations standard it may not be cost effective to apply additional insulation. Because of this the Committee on Climate Change propose an under insulated loft as one with less than 125mm of existing insulation. Dwellings recorded as having a depth of insulation below that required to meet the threshold U-value of 0.35 W/m^{2}K are assigned as uninsulated. Table 19 summarises these threshold depths, along with the building regulations target for the improvement of retained thermal elements.

Table 19 – Depth required to meet target and threshold U-value, by insulation material[31]

	Mineral wool / fibre glass	Rigid foam board	High performance quilt	Vermiculite beads
Thermal conductivity W/mk	0.044	0.022	0.044	0.063
Uninsulated U-value W/m^{2}K	2.30	2.30	2.30	2.30
Threshold U-value*	0.35	0.35	0.35	0.35
Thickness to achieve threshold U-value (mm)	126	63	126	180
Target U-value	0.16**	0.18***	0.16**	0.16**
Thickness to achieve target U-value (mm)	219	113	219	323

* The threshold U-value in building regulations for retained thermal elements is 0.35 W/m^{2}k for all roof types (pitched, flat)
** For loft insulation at ceiling level
*** For loft insulation at rafter level

6.1.4 Stage 4: Account for installations under Government Schemes and new builds

The number of dwellings that have received loft insulation under Government schemes since the baseline year of 2008 is then subtracted from the estimated number of uninsulated dwellings. Table 20 summarises these numbers, grouped across three types of installation treated as follows:

- "Loft insulation" – is subtracted from the number of dwellings with an uninsulated "standard" loft (pitched, accessible). Whilst a small number of these installs are at "rafter level", it is assumed that this is not equivalent to full room-in-roof insulation (for either converted or as built).
- "Room-in-roof insulation" – is subtracted from the number of dwellings with an uninsulated converted room-in-roof (not mansard or chalet roof dwellings).
- "Flat roof insulation" – is subtracted from the number of dwellings recorded as having an uninsulated flat roof.

[31] These are the only insulation materials recorded in the housing survey datasets.

Table 20 – Number of lofts insulated under Government Schemes 2008 to 2015; (source: DECC, 2015[32])

Measure type	CERT, CESP, Warm Front	Green Deal* (to Oct-15)	ECO* (to Sep-15)	Total
Loft insulation (inc. virgin, top-up, rafter)	5,500,000	1,854	412,337	5,914,191
Room in roof insulation	-	211	7,359	7,570
Flat roof insulation	-	169	1,301	1,470

* it is noted in the data source that there may be a small number of measures double counted under GD finance, ECO, Cashback or GDHIF.

The number of new build dwellings between 2008 and 2015 is added to the total number of dwellings – split across insulated standard dwellings and insulated flat roof (non-standard) dwellings. Consistent with the DECC insulation estimates methodology, these

Based on DCLG estimates on new builds, 989,660 dwellings were built in England, Scotland and Wales between 2008/09 and 2014/15. The majority of these (67%) are houses and assumed to have a loft. Of those that are flats, 60% are assumed not to have a loft and are added to the "no loft" category; for comparability with the DECC methodology.

6.2 Quantifying the potential carbon impact

All carbon savings have been calculated using SAP 2012, the standard methodology used by the Government to assess and compare the energy and environmental performance of dwellings.

National savings have been scaled up based on modelled savings calculated for a range of archetype properties specified to represent the GB housing stock. These archetypes are formed from 7 types of dwelling[33] and 4 different heating fuels (gas, oil, electric, solid). The average saving for each building type was calculated by generating a fuel weighted saving (see Table 83 for fuel weightings). These weighted savings were multiplied up by the total number of dwellings of each building type that had the potential to have insulation installed, as quantified in the previous section.

A summary of modelling assumptions common with the quantification for non-standard cavity walls can be found in Appendix 3. In this section we present only a selection of modelling inputs needed to understand the loft insulation scenarios modelled.

Table 21 and Table 22 show the fabric U-value assumptions for walls and loft elements, used in the modelling of the carbon impact of loft insulation. Post-installation U-values were set at building regulations requirements – making the assumption that these could be met cost-effectively and without compromising head height.

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[32] DECC (November 2015): Green Deal and Energy Company Obligation (ECO): headline statistics (November 2015). Available at: https://www.gov.uk/government/collections/green-deal-and-energy-company-obligation-eco-statistic; [accessed Jan 2016]

[33] Two fewer than were modelled for the non-standard wall savings provided in this report due to the assumption that there is no potential to insulate "ground floor" or "mid floor" flats, since these do not have a roof area exposed to unheated space.

Table 21 – Fabric assumptions of modelled property archetypes

Dwelling Type	% windows double glazed	Wall U-value W/m^2K	Party wall U-value W/m^2K
Detached bungalow	94%	1.37	0.5
Detached house	89%	1.37	0.5
End terraced house	90%	1.48	0.5
Mid terraced house	87%	1.59	0.5
Semi-detached bungalow	94%	1.42	0.5
Semi-detached house	92%	1.42	0.5
Top floor flat	81%	1.42	0.5

Table 22 – Impact of installating loft insulation of U-values of each loft element

Loft element	U value before W/m^2K	U value after W/m^2K	Change in U-value
Ceiling / roof level	2.30	0.16	2.14
Rafter level	2.30	0.18	2.12
Flat roof	2.30	0.18	2.12
Mansard wall	1.90	0.55	1.35
Dwarf wall	2.30	0.30	2.00
Gable wall	*as assumed wall value*	*unchanged*	-
Party wall	*as assumed wall value*	*unchanged*	-

To compensate for the observed difference between modelled and in-situ energy savings we apply DECC Green Deal in-use factors[34]; see Table 23. A 15% comfort factor has also been applied[35]. These reduction factors are applied to the estimates after the energy saving has been modelled.

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[34] DECC (2012) How the Green Deal will reflect the in-situ performance of energy efficiency measures. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/383547/5505-how-the-green-deal-will-reflect-the-insitu-perfor.pdf; [accessed Jan 2016]

[35] Sanders, C., Phillipson, M., (2008) An Analysis of the Difference between Measured and Predicted Energy Savings when Houses are Insulated. Available at: http://web.byv.kth.se/bphys/copenhagen/pdf/089-2.pdf; [accessed Jan 2016]

Table 23 – In-use factors applied to modelled energy savings from loft insulation measures

Measure	In-use factor	Comfort factor
Standard loft insulation (virgin and top-up)	35%	15%
Flat roof insulation	15%	15%
Room-in-roof insulation	25%	15%
Mansard roof insulation	25%	15%
Chalet roof insulation	25%	15%

6.3 Quantifying the potential cost

Finally, the cost of installing insulation in non-standard lofts has been estimated for each dwelling type, as well as an indicative national cost of insulating all unfilled dwellings.

Table 24 summarises the cost inputs used in this exercise. These costs are based on synthesis of:

- Cost estimates provided to the stakeholder survey
- Industry pricing books[36,37]
- Secondary cost research online and in scheme reporting, including estimates held in the Energy Saving Trust Cost Database[38]
- Feedback given at the stakeholder workshop on typical costs presented[39]

For modelling purposes, these have been disaggregated into fixed and variable per m^2 costs. The variable cost has been further broken down in the table below in order to present material and labour costs separately.

These costs do not include:

- Redecoration
- Unusual detailed work around lights and internal fittings
- Structural / reinforcement of ceiling to support weight of insulant
- Internal scaffold to reach ceiling areas

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[36] Davis Langdon (2013): SPON's Architects' and Builders' Price Book 2013. Spon Press, 138th ed.
[37] Spain, B. (2010): SPON's House Improvement Price Book. Spon Press, 4th ed.
[38] This is a cost database resource maintained by EST, which brings together evidence from installer quotes, secondary internet and literature research, price book estimates, and cost data from retrofit schemes.
[39] There was a concern that the estimates presented at that workshop may have under-reported the total cost of insulating room-in-roof spaces (including mansard). This has been taken into account in the estimates used for the modelling presented in this report, by selecting costs from the upper ranges of the estimates gathered through the research. This will be further improved in the cost extension to this work (Section 2.4).

- Lead generation / survey
- Overheads and profit[40]

A further, more comprehensive, cost exercise is scheduled to take place as an extension to this study; see Section 2.4 for details.

In particular it should be noted, as recognised in Section 5.2.2, that “cold deck” flat roof insulation whereby insulation is placed below the roof structure, is not the favoured approach to insulating flat roofs due to the risk of condensation. Costs for insulating a dwelling in this way have been used in this analysis as these were those quoted during the stakeholder survey. It is likely that the cost of re-covering in order to apply insulate above the roof structure is higher; however this was not an approach familiar to those stakeholders that we spoke to for this project.

Respondents to the stakeholder survey identified a number of factors which may influence the cost of undertaking loft insulation. Some costs, such as lifting and replacing roof tiles to insulate over the rafters, may be prohibitive if undertaken with the sole purpose of installing insulate. However these costs can be avoided if opportunities present themselves; for example where re-roofing takes place.

A final real-world cost factor which should be considered is the lifetime of roof insulation measures. External weatherproof layers, whether tiles or a flat roof covering, will require routine upgrading and the performance of insulation materials will also degrade over time.

[40] It was difficult to account for the inclusion of O&P costs across cost estimates from different sources, however the majority of sources used to derive our cost inputs did not include these.

Table 24 - Summary of cost inputs for the quantification of non-standard loft insulation costs in GB

Loft type	Material cost (per m²)	Labour cost (per m²)	Other cost	Typical cost*
Standard pitched	£1.80	£2.00	-	£185
Mineral wool rolled between and across ceiling joists to a depth of 270mm, no loft clearance or impediments to access				
Standard pitched + access issues	£1.80	£2.00	£150	£335
As above, with additional cost for creation or expansion of loft hatch to access loft space				
Standard pitched + loft clearance	£1.80	£2.00	£100-300	£385
As above, with additional cost for clearance of loft prior to installation				
Room-in-roof	£15.00	£10.00	£100	£1,250
PIR rigid insulation board (50mm insulation, 12.5mm plasterboard) between and battened to underside of sloping rafter areas, and affixed to any dummy wall areas. Mineral wool laid across any concealed ceiling areas, with additional cost for access				
Flat roof	£15.00	£12.00	-	£1,320
Internal "cold deck" insulation, with PIR rigid insulation board (50mm insulation, 12.5mm plasterboard) affixed to ceiling. No internal scaffold cost included.				
Mansard roof	£15.00	£10.00		£1,890
PIR rigid insulation board (50mm insulation, 12.5mm plasterboard) between / across mansard wall stud, and affixed to ceiling (assuming no accessible loft cavity). Does not include dormers.				
Chalet roof	£12.00	£8.00	-	£1,140
PIR rigid insulation board (50mm insulation, 12.5mm plasterboard), between and battened to underside of sloping rafter sections				

* to treat a typical 3-bed semi-detached house

** see comment in text above table

7 Quantifications of non-standard cavity walls and lofts

7.1 The number of dwellings with non-standard cavity walls, the cost to treat and potential carbon savings

In this section we present tables of the quantified estimates for non-standard cavity walls in GB. These are presented by **dwelling type** and **dwelling age**, for the following non-standard cavity wall types:

- Narrow cavities
- Stone cavities
- Metal frame
- Concrete construction
- Partially filled cavities
- Timber frame construction with masonry cavity and uninsulated studwork
- Timber frame with uninsulated studwork but without masonry cavity
- Party wall bypass cavity
- Mixed construction
- Tile hanging or other cladding on wall
- Access issues
- Too high
- Wall faults: Structural, finish or damp proof course
- Exposed locations

For each of these, the following metrics are presented:

- Total number of dwellings within each non-standard classification – both insulated and uninsulated
- Number of these which are uninsulated
- Total indicative cost to insulate all of these dwellings (£)
- Typical cost to insulate per property (£)
- Total carbon saving potential achievable by insulating all of these dwellings (T CO_2/year)
- Average estimated carbon saving achievable by insulating per property (T CO_2/year)

We have also provided estimates for the number of insulated and uninsulated cavity wall dwellings in flood risk areas – by Environment Agency flood risk category and dwelling type.

See Section 4.1 for the methodology for quantifying the number of dwellings, Section 4.2 for the methodology for modelling the potential carbon savings achievable by insulating, and Section 4.3 for the methodology for estimating typical costs.

7.1.1 Standard cavity

Table 25 – Estimated number of dwellings with standard cavity walls, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	32 - 57	1,910 - 2,070	933 - 1,050	1,360 - 1,500	1,560 - 1,700	2,510 - 2,690	8,540 - 8,830
Number of fillable dwellings (000s)	24 - 46	380 - 456	221 - 280	496 - 582	487 - 573	569 - 662	2,300 - 2,480
Cost to insulate (£M)	£2.41 - £4.65	£229 - £275	£59.8 - £75.9	£75.3 - £88.5	£49.3 - £57.9	£163 - £189	£612 - £658
Carbon saving ($kTCO_2$ / yr)	6.5 - 12	350 - 420	110 - 140	140 - 170	130 - 160	280 - 330	1100 - 1200
Average cost per home	£101	£603	£271	£152	£101	£286	£266
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.475

Table 26 – Estimated number of dwellings with standard cavity walls in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	894 - 1,010	1,890 - 2,050	1,240 - 1,380	677 - 777	1,070 - 1,190	1,240 - 1,370	1,230 - 1,360	8,540 - 8,830
Number of fillable dwellings (000s)	475 - 560	628 - 724	65 - 99	3 - 15	416 - 496	410 - 489	170 - 223	2,300 - 2,480

7.1.2 Narrow Cavity

Table 27 – Estimated number of dwellings with narrow cavity walls, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	8 - 23	90 - 130	41 - 69	97 - 137	34 - 60	167 - 219	494 - 580
Number of fillable dwellings (000s)	7 - 21	15 - 34	8 - 22	52 - 83	8 - 22	44 - 72	168 - 220
Cost to insulate (£M)	£0.98 - £2.99	£13.2 - £29.3	£2.97 - £8.58	£11.3 - £18	£1.1 - £3.2	£17.8 - £29.5	£60.2 - £78.9
Carbon saving (kT CO_2 / yr)	1.7 - 5.2	13 - 29	3.5 - 10	14 - 22	1.9 - 5.6	20 - 33	69 - 91
Average cost per home	£145	£861	£387	£217	£145	£409	£359
Average CO_2 saving per home (T CO_2/yr)	0.251	0.852	0.460	0.269	0.255	0.459	0.413

Table 28 – Estimated number of dwellings with narrow cavity walls in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	139 - 187	149 - 198	63 - 97	22 - 43	8 - 22	11 - 28	40 - 68	494 - 580
Number of fillable dwellings (000s)	81 - 119	8 - 23	25 - 48	9 - 24	3 - 14	4 - 15	2 - 13	168 - 220

7.1.3 Stone cavity

Table 29 – Estimated number of dwellings with stone cavity walls, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	0 - 2	114 - 157	14 - 32	12 - 29	4 - 15	91 - 130	267 - 332
Number of fillable dwellings (000s)	0 - 2	25 - 48	0 - 6	0 - 6	0 - 4	19 - 40	58 - 90
Cost to insulate (£M)	£0 - £0.242	£24.1 - £45.7	£0 - £2.65	£0 - £1.32	-	£8.68 - £17.9	£39.4 - £61.4
Carbon saving (kT CO_2 / yr)	-	22 - 41	0 - 2.9	0 - 1.5	-	8.9 - 18	37 - 58
Average cost per home	-	£947	£426	£239	-	£450	£680
Average CO_2 saving per home (T CO_2/yr)	-	0.852	0.460	0.269	-	0.459	0.642

Table 30 – Estimated number of dwellings with stone cavity walls, and the cost and carbon saving potential of these in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	2 - 11	28 - 52	59 - 92	46 - 76	23 - 45	21 - 42	37 - 64	267 - 332
Number of fillable dwellings (000s)	0 - 4	6 - 20	10 - 26	7 - 21	8 - 22	6 - 19	0 - 1	57.9 - 90.2

7.1.4 Metal Frame

Table 31 – Estimated number of dwellings with metal frame cavity walls and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	0 - 2	37 - 64	3 - 14	2 - 11	17 - 36	36 - 62	119 - 164
Number of fillable dwellings (000s)	0 -	0 - 4	0 - 1	0 - 2	0 - 4	1 - 10	68 - 80
Cost to insulate (£M)	£0 - £0	£0 - £5.1	£0 - £0.844	£0 - £0.66	£0 - £0.915	£0.691 - £6.3	£45 - £52.6
Carbon saving (kT CO_2 / yr)	0 - 0	0 - 2.7	0 - 0.53	0 - 0.43	0 - 0.85	0.41 - 3.7	27 - 31
Average cost per home	£225	£1,343	£604	£339	£225	£638	£659
Average CO_2 saving per home (T CO_2/yr)	0.205	0.708	0.380	0.220	0.208	0.379	0.392

Table 32 – Estimated number of dwellings with metal frame cavity walls in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	0 -	5 - 18	34 - 60	12 - 29	4 - 15	6 - 19	29 - 53	119 - 164
Number of fillable dwellings (000s)	0 -	0 - 2	1 - 11	0 - 4	0 - 1	0 - 3	0 -	3.71 - 15.3

7.1.5 Concrete construction

Table 33 – Estimated number of dwellings with concrete construction cavity walls and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	0 -	6 - 20	17 - 37	37 - 64	388 - 465	82 - 120	572 - 665
Number of fillable dwellings (000s)	0 -	0 -	0 - 2	0 - 8	92 - 132	14 - 32	118 - 162
Cost to insulate (£M)	£0 - £0	£0 - £0.536	£0 - £1.47	£0.147 - £3	£22.6 - £32.3	£9.49 - £21.9	£38 - £52.3
Carbon saving (kT CO_2 / yr)	0 - 0	0 - 0.26	0 - 0.85	0.088 - 1.8	19 - 28	5.2 - 12	28 - 38
Average cost per home	£244	£1,455	£654	£367	£244	£691	£323
Average CO_2 saving per home (T CO_2/yr)	0.205	0.708	0.380	0.220	0.208	0.379	0.237

Table 34 – Estimated number of dwellings with concrete construction cavity walls in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	0 -	9 - 24	229 - 290	196 - 252	47 - 76	16 - 35	21 - 42	572 - 665
Number of fillable dwellings (000s)	0 -	2 - 12	22 - 43	56 - 87	12 - 28	3 - 15	0 -	118 - 162

7.1.6 Timber frame with masonry cavity and uninsulated studwork

Table 35 – Estimated number of dwellings with timber frame with masonry cavity and uninsulated studwork, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	0 - 3	24 - 46	15 - 33	13 - 30	6 - 19	22 - 43	104 - 146
Cost to insulate (£M)	£0 - £0.578	£26.5 - £51.3	£7.31 - £16.5	£3.56 - £8.45	£1.07 - £3.55	£11.4 - £22.8	£63.7 - £89.3
Carbon saving (kT CO_2 / yr)	0 - 0.62	17 - 33	5.7 - 13	2.8 - 6.6	1.2 - 4	8.4 - 17	46 - 64
Average cost per home	£188	£1,119	£503	£282	£188	£532	£610
Average CO_2 saving per home (T CO_2/yr)	0.200	0.730	0.390	0.220	0.210	0.390	0.436

Table 36 – Estimated number of dwellings with timber frame with masonry cavity and uninsulated studwork walls in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	2 - 12	0 - 7	8 - 23	30 - 54	43 - 71	0 -	0 -	104 - 146

7.1.7 Timber Frame Masonry Cavity with Uninsulated Studwork

Table 37 – Estimated number of dwellings with timber frame masonry cavity with uninsulated studwork and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of fillable dwellings (000s)	1 - 9	58 - 90	5 - 18	16 - 34	0 - 6	21 - 42	127 - 173
Cost to insulate (£M)	£0.136 - £1.69	£64.9 - £101	£2.69 - £9.18	£4.38 - £9.67	£0 - £1.1	£11.1 - £22.3	£96.7 - £132
Carbon saving (kT CO_2 / yr)	0.13 - 1.7	39 - 60	1.9 - 6.4	3.1 - 6.9	0 - 1.1	7.3 - 15	60 - 82
Average cost per home	£188	£1,119	£503	£282	£188	£532	£761
Average CO_2 saving per home (T CO_2/yr)	0.186	0.664	0.353	0.202	0.189	0.351	0.473

Table 38 – Estimated number of dwellings with timber frame masonry cavity with uninsulated studwork in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of fillable dwellings (000s)	46 - 75	8 - 22	23 - 45	12 - 30	12 - 29	0 -	0 -	127 - 173

7.1.8 Partial Fill

Table 39 – Estimated number of dwellings with partial fill cavity walls, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	0 - 1	223 - 282	47 - 76	40 - 68	121 - 166	87 - 126	572 - 664
Cost to insulate (£M)	£0 - £0.0775	£153 - £194	£14.4 - £23.5	£6.99 - £11.8	£14 - £19.2	£28.6 - £41.2	£235 - £273
Carbon saving (kT CO_2 / yr)	0 - 0.014	18 - 23	1.9 - 3.1	0.91 - 1.5	2.5 - 3.5	3.5 - 5.1	29 - 34
Average cost per home	£116	£689	£310	£174	£116	£327	£411
Average CO_2 saving per home (T CO_2/yr)	0.021	0.080	0.041	0.023	0.021	0.041	0.051

Table 40 – Estimated number of dwellings with partial fill cavity walls in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	-	-	-	-	-	-	572 - 664	572 - 664

7.1.9 Standard Cavity with Issues

Table 41 – Estimated number of dwellings with standard cavity walls with at least one issue, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	49 - 79	2,420 - 2,600	688 - 789	956 - 1,070	1,410 - 1,550	2,670 - 2,850	8,430 - 8,720
Number of fillable dwellings (000s)	32 - 56	500 - 587	156 - 207	378 - 454	447 - 529	619 - 715	2,250 - 2,430
Cost to insulate (£M)	£46.1 - £82.5	£1660 - £1950	£327 - £432	£624 - £749	£654 - £774	£1330 - £1540	£4890 - £5270
Carbon saving (kTCO_2 / yr)	8.5 - 15	470 - 550	78 - 100	110 - 130	120 - 150	310 - 360	1200 - 1200
Average cost per home	£1,462	£3,321	£2,091	£1,650	£1,462	£2,149	£2,172
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.512

Table 42 – Estimated number of dwellings with standard cavity walls with at least one issue in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	326 - 397	1,270 - 1,400	2,100 - 2,260	1,890 - 2,050	741 - 846	862 - 974	954 - 1,070	8,430 - 8,720
Number of fillable dwellings (000s)	190 - 245	8 - 23	25 - 48	9 - 24	3 - 14	4 - 15	2 - 13	168 - 220

7.1.10 Too High

Table 43 – Estimated number of dwellings with standard cavity walls that are too high, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	2 - 13	0 - 2	0 - 5	4 - 15	724 - 828	0 - 6	746 - 851
Number of fillable dwellings (000s)	1 - 10	0 - 2	0 - 5	1 - 10	462 - 546	0 - 6	478 - 563
Cost to insulate (£M)	£0.874 - £8.55	£0 - £12.3	£0 - £12.3	£1.31 - £12.8	£409 - £483	£0 - £14.1	£435 - £512
Carbon saving (kTCO_2 / yr)	0.27 - 2.6	0 - 2.2	0 - 2.6	0.29 - 2.8	130 - 150	0 - 2.8	130 - 160
Average cost per home	£885	£5,275	£2,371	£1,330	£885	£2,506	£911
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.278

Table 44 – Estimated number of dwellings with standard cavity walls that are too high in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	1 - 9	131 - 178	148 - 197	135 - 182	42 - 70	66 - 100	145 - 194	746 - 851
Number of fillable dwellings (000s)	0 - 8	71 - 106	85 - 123	93 - 133	24 - 46	56 - 88	84 - 122	478 - 563

7.1.11 Conservatory

Table 45 – Estimated number of dwellings with standard cavity walls that have a conservatory, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	0 - 3	1,190 - 1,320	146 - 195	159 - 209	7 - 21	893 - 1,010	2,480 - 2,660
Number of fillable dwellings (000s)	0 - 2	209 - 267	0 -	34 - 59	2 - 11	105 - 147	379 - 455
Cost to insulate (£M)	£0 - £1.35	£264 - £336	£0 - £0.391	£20.7 - £36.5	£0.921 - £6.13	£84.5 - £119	£394 - £474
Carbon saving ($kTCO_2$ / yr)	0 - 0.67	190 - 250	0 - 0.25	9.8 - 17	0.47 - 3.1	52 - 73	270 - 330
Average cost per home	£545	£1,261	£787	£617	£545	£809	£1,041
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.719

Table 46 – Estimated number of dwellings with standard cavity walls that have a conservatory walls that are in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	46 - 75	285 - 352	552 - 642	500 - 587	225 - 284	351 - 424	372 - 448	2,480 - 2,660
Number of fillable dwellings (000s)	17 - 37	75 - 111	3 - 14	30 - 55	40 - 67	136 - 183	22 - 44	379 - 455

7.1.12 Panels

Table 47 – Estimated number of dwellings with standard cavity walls that have panelling on the walls, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	1 - 9	447 - 529	155 - 205	282 - 349	369 - 444	418 - 498	1,770 - 1,930
Number of fillable dwellings (000s)	0 - 8	52 - 83	36 - 62	129 - 176	130 - 176	29 - 53	427 - 507
Cost to insulate (£M)	£0.0397 - £1.13	£44.6 - £71	£14 - £24.2	£28.1 - £38.1	£18.8 - £25.5	£11.9 - £21.7	£137 - £162
Carbon saving ($kTCO_2$ / yr)	0.074 - 2.1	48 - 77	18 - 31	38 - 51	36 - 48	14 - 27	180 - 210
Average cost per home	£145	£861	£387	£217	£145	£409	£320
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.418

Table 48 – Estimated number of dwellings with standard cavity walls that have panelling on the walls in GB 2015, by dwelling age

	Pre 1850	1850 to 1899	1900 to 1918	1919 to 1944	1945 to 1964	1965 to 1974	1975 to 1980	Grand Total
Number of dwellings (000s)	6 - 19	36 - 62	232 - 293	692 - 793	246 - 308	199 - 256	251 - 314	1,770 - 1,930
Number of fillable dwellings (000s)	5 - 18	16 - 35	113 - 156	124 - 169	34 - 59	66 - 101	12 - 29	427 - 507

7.1.13 Mixed wall

Table 49 – Estimated number of dwellings with standard cavity walls along with other wall types, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	6 - 19	186 - 241	89 - 128	155 - 205	161 - 212	296 - 364	971 - 1,090
Number of fillable dwellings (000s)	0 - 6	46 - 76	22 - 44	65 - 98	71 - 106	84 - 123	334 - 406
Cost to insulate (£M)	£0 - £0.879	£39.8 - £65.1	£8.51 - £16.8	£14 - £21.3	£10.2 - £15.3	£34.5 - £50.1	£125 - £152
Carbon saving ($kTCO_2$ / yr)	0 - 1.6	43 - 70	11 - 22	19 - 29	19 - 29	42 - 61	160 - 190
Average cost per home	£145	£861	£387	£217	£145	£409	£374
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.470

Table 50 – Estimated number of dwellings with standard cavity walls along with other wall types in GB 2015, by dwelling age

	Pre 1850	1850 to 1899	1900 to 1918	1919 to 1944	1945 to 1964	1965 to 1974	1975 to 1980	Grand Total
Number of dwellings (000s)	114 - 158	140 - 188	218 - 277	258 - 322	63 - 97	59 - 91	26 - 49	971 - 1,090
Number of fillable dwellings (000s)	69 - 104	44 - 73	40 - 67	92 - 132	14 - 32	23 - 44	0 - 6	334 - 406

7.1.14 Exposed Wall

Table 51 – Estimated number of dwellings with standard cavity walls that are exposed, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	0 - 8	283 - 349	20 - 41	29 - 53	148 - 197	76 - 112	610 - 706
Number of fillable dwellings (000s)	0 - 4	9 - 24	9 - 24	0 - 6	2 - 13	9 - 24	47 - 76
Cost to insulate (£M)	£0 - £3.33	£40.7 - £112	£18.2 - £50.3	£0 - £7.61	£1.85 - £10	£20.3 - £54.8	£121 - £197
Carbon saving ($kTCO_2$ / yr)	0 - 1.1	8 - 22	4.3 - 12	0 - 1.9	0.64 - 3.5	4.5 - 12	26 - 43
Average cost per home	£795	£4,735	£2,129	£1,194	£795	£2,250	£2,602
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.570

Table 52 – Estimated number of dwellings with standard cavity walls that areexposed in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	6 - 19	113 - 156	115 - 159	114 - 157	49 - 79	72 - 108	67 - 101	610 - 706
Number of fillable dwellings (000s)	0 - 6	2 - 11	3 - 14	0 - 4	0 - 2	24 - 46	2 - 11	46.5 - 75.8

7.1.15 Structural Fault

Table 53 – Estimated number of dwellings with standard cavity walls that have structural faults, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	0 - 8	63 - 97	49 - 79	59 - 92	90 - 129	182 - 237	500 - 586
Number of fillable dwellings (000s)	0 - 7	9 - 24	4 - 15	18 - 38	28 - 51	34 - 60	121 - 166
Cost to insulate (£M)	£0 - £25.3	£40.3 - £110	£15.4 - £63.4	£72.8 - £152	£107 - £199	£142 - £249	£496 - £680
Carbon saving (kTCO_2 / yr)	0 - 1.8	8.2 - 22	1.9 - 7.7	5.3 - 11	7.6 - 14	17 - 30	53 - 73
Average cost per home	£3,895	£4,611	£4,137	£3,967	£3,895	£4,159	£4,093
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.441

Table 54 – Estimated number of dwellings with standard cavity walls that have structural faults in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	40 - 67	109 - 152	160 - 210	72 - 108	35 - 62	16 - 35	4 - 16	0 -
Number of fillable dwellings (000s)	24 - 46	33 - 58	12 - 30	10 - 26	7 - 21	3 - 14	0 - 4	121 - 166

7.1.16 Finish Fault

Table 55 – Estimated number of dwellings with standard cavity walls that have finish faults, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	26 - 48	439 - 521	257 - 321	336 - 408	323 - 393	1,030 - 1,150	2,530 - 2,720
Number of fillable dwellings (000s)	23 - 45	101 - 142	71 - 106	151 - 201	152 - 202	304 - 373	879 - 992
Cost to insulate (£M)	£32.7 - £63.8	£216 - £304	£118 - £176	£225 - £300	£216 - £287	£513 - £628	£1450 - £1630
Carbon saving ($kTCO_2$ / yr)	6.2 - 12	94 - 130	36 - 53	44 - 58	42 - 56	150 - 190	410 - 460
Average cost per home	£1,420	£2,136	£1,662	£1,492	£1,420	£1,684	£1,645
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.466

Table 56 – Estimated number of dwellings with standard cavity walls that have finish faults in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	162 - 214	600 - 694	857 - 968	494 - 580	151 - 201	95 - 135	37 - 64	2,530 - 2,720
Number of fillable dwellings (000s)	114 - 158	261 - 325	193 - 249	144 - 192	34 - 59	52 - 83	0 - 7	879 - 992

7.1.17 DPC Fault

Table 57 – Estimated number of dwellings with standard cavity walls that have dpc faults, and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)	3 - 14	245 - 307	82 - 119	125 - 170	133 - 180	342 - 415	1,010 - 1,130
Number of fillable dwellings (000s)	1 - 10	39 - 66	10 - 26	37 - 64	23 - 45	42 - 70	188 - 243
Cost to insulate (£M)	£4.03 - £32.5	£148 - £253	£33 - £86.4	£119 - £205	£71.7 - £140	£143 - £238	£643 - £831
Carbon saving ($kTCO_2$ / yr)	0.35 - 2.8	36 - 61	4.9 - 13	11 - 19	6.3 - 12	21 - 35	97 - 120
Average cost per home	£3,145	£3,861	£3,387	£3,217	£3,145	£3,409	£3,423
Average CO_2 saving per home (TCO_2/yr)	0.271	0.932	0.501	0.291	0.275	0.499	0.514

Table 58 – Estimated number of dwellings with standard cavity walls that have dpc faults in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	45 - 74	178 - 231	274 - 339	188 - 243	69 - 104	79 - 116	79 - 116	1,010 - 1,130
Number of fillable dwellings (000s)	23 - 45	44 - 72	8 - 23	13 - 30	5 - 17	43 - 71	11 - 27	188 - 243

7.1.18 Party Wall

Table 59 – Estimated number of dwellings with bypass party cavity walls and the cost and carbon saving potential of these in GB 2015, by dwelling type

	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	Total
Number of dwellings (000s)			1,160 - 1,290	1,550 - 1,700		3,160 - 3,360	5,980 - 6,240
Cost to insulate (£M)			£421 - £468	£473 - £518		£1170 - £1250	£2110 - £2200
Carbon saving ($kTCO_2$ / yr)			75 - 84	210 - 230		200 - 210	490 - 510
Average cost per home			£363	£305[41]		£372	£352
Average CO_2 saving per home (TCO_2/yr)			0.065	0.132		0.063	0.082

Table 60 – Estimated number of dwellings with bypass party cavity walls in GB 2015, by dwelling age

	Pre 1919	1919-1944	1945-1964	1965-1974	1975-1980	1981-1990	Post 1990	Grand Total
Number of dwellings (000s)	0 -	-	1,650 - 1,800	1,740 - 1,890	714 - 817	694 - 795	1,000 - 1,120	5980 - 6240

[41] This is the cost to insulate only 1 wall of the mid terrace – CO2 saving assumes both party walls are insulated.

7.1.19 Flood risk areas

In order to quantify the number of dwellings in flood risk areas we analysed the National Flood Risk Assessment (NaFRA) Property Flood Likelihood Category (FLC) Database published by the Environment Agency[42]. This groups every property in England and Wales by flood risk according to 5 categorisations (Table 61).

This dataset was matched with the EST Home Analytics housing database, in order to assign a flood risk level to every individual dwelling (for which Home Analytics contains information on the building characteristics). There are an estimated 373,000 dwellings in Medium, and 211,000 dwellings in High, flood risk areas in Great Britain (Table 62).

Table 61 – Definition of Environment Agency flood risk categories

Flood risk category	Description
“None”	Not in a flood risk zone identified by Environment Agency
“Very Low”	Each year, there is a chance of flooding less than 1 in 1000 (0.1%)
“Low”	Each year, there is a chance of flooding between 1 in 100 (1%) and 1 in 1000 (0.1%)
“Medium”	Each year, there is a chance of flooding between 1 in 30 (3.3%) and 1 in 100 (1%)
“High”	Each year, there is a chance of flooding greater than 1 in 30 (3.3%)

Table 62 – Estimated number of dwellings in flood risk areas in GB, by flood risk category

Flood risk	All dwelling types
Low / Very Low / None (000s)[43]	27,726
Medium (000s)	373
% all dwellings in medium flood risk	1.3%
High (000s)	211
% all dwellings in high flood risk	0.7%

The outputs of this analysis are a breakdown of the estimated number of dwellings with insulated and uninsulated cavity walls in Medium (Table 63) and High (Table 64) flood risk areas.
The key points to note from these estimates are that:

- As typical in Great Britain as a whole, the majority of dwellings in flood risk areas have cavity walls; we estimate this to be 365,260 dwellings.
- An estimated 126,899 of these are in areas which have a chance of flooding greater than once in 30 years (High flood risk), with the majority (75.5%) of these already insulated.

[42] Available online at: http://www.geostore.com/environment-agency/WebStore?xml=staticweb/xml/dataLayers_NaFRAPFLCG.xml; [accessed Dec 2015]
[43] The total number of GB dwellings in this analysis differs from the rest of the report as they are from a different source.

Table 63 – Estimated number of dwellings in Medium flood risk category areas in GB, by wall type and dwelling type

Flood risk: Medium	Converted flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	All dwelling types
All dwellings (000s)	31	81	36	64	65	96	373
Dwellings with cavity walls (000s)	18	67	20	27	33	73	238
% all dwellings with cavity walls	58.3%	83.0%	54.3%	42.9%	50.5%	76.4%	63.9%
Dwellings with insulated cavity walls (000s)	15	63	13	14	26	60	191
% cavity wall dwellings insulated	81.4%	93.9%	66.0%	52.0%	79.5%	81.7%	80.1%
Dwellings with uninsulated cavity walls (000s)	3	4	7	13	7	13	47
% cavity wall dwellings uninsulated	18.6%	6.1%	34.0%	48.0%	20.8%	18.2%	19.9%

Table 64 – Estimated number of dwellings in High flood risk category areas in GB, by wall type and dwelling type

Flood risk: High	Converted flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	All dwelling types
All dwellings (000s)	20	45	18	30	64	35	211
Dwellings with cavity walls (000s)	11	35	10	14	32	26	127
% all dwellings with cavity walls	54.1%	76.2%	54.5%	46.9%	50.2%	74.9%	60.1%
Dwellings with insulated cavity walls (000s)	8	32	6	6	24	20	96
% cavity wall dwellings insulated	74.5%	91.6%	61.5%	45.1%	74.0%	78.1%	75.5%
Dwellings with uninsulated cavity walls (000s	3	3	4	8	8	6	31
% cavity wall dwellings uninsulated	25.5%	8.4%	38.5%	54.9%	26.0%	21.9%	24.5%

7.2 The number of dwellings with non-standard lofts, the cost to treat and potential carbon savings

In this section we present tables of the quantified estimates for dwellings with non-standard lofts in GB. These are presented by **dwelling type** and **dwelling age**, for the following non-standard loft types:

- Standard lofts with access issues
- Flat roofs
- Room-in-roofs
- Mansard roofs
- Chalet roofs

For each of these, the following metrics are presented:

- Total number of dwellings within each non-standard classification – both insulated and uninsulated
- Number of these which are uninsulated
- Total indicative cost to insulate all of these dwellings (£)
- Typical cost to insulate per property (£)
- Total carbon saving potential achievable by insulating all of these dwellings (T CO_2/year)
- Average estimated carbon saving achievable by insulating per property (T CO_2/year)

Also provided are estimates for the number dwellings with roof faults. These are provided for both structural and covering faults, and are split across dwelling type and age.

See Section 6.1 for the methodology for quantifying the number of dwellings, Section 6.2 for the methodology for modelling the potential carbon savings achievable by insulating, and Section 6.3 for the methodology for estimating typical costs.

7.2.1 Standard lofts with access issues

Table 65 – Estimated number of standard lofts with access issues, and the cost and carbon saving potential of these in GB 2015, by dwelling type

Quantification by dwelling type	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	All dwelling types
Estimated total number (000s)	10 - 25	394 - 471	144 - 192	319 - 389	60 - 92	574 - 666	1,594 - 1,742
Number with insulation potential (000s)	8 - 22	244 - 305	95 - 135	219 - 278	16 - 35	390 - 466	1,046 - 1,168
Cost to insulate all dwellings (£m)	£2.9 - £8.4	£103.8 - £130.1	£28.6 - £40.6	£65.7 - £83.3	£6.3 - £13.5	£130.7 - £156.4	£338.0 - £432.2
Typical cost per dwelling	£380	£430	£300	£300	£380	£340	£300 - £430
Carbon saving potential from all dwellings ($kTCO_2$ / yr)	1.0 - 23.4	26.8 - 274.6	5.7 - 67.7	13.2 - 141.7	2.1 - 37.6	27.3 - 275.2	76.0 - 820.2
Average CO_2 saving per home - virgin loft insulation (TCO_2/yr)	1.06	0.90	0.50	0.51	1.06	0.59	0.66
Average CO_2 saving per home - top-up from 120mm (TCO_2/yr)	0.13	0.11	0.06	0.06	0.13	0.07	0.08

Table 66 – Estimated number of standard lofts with access issues in GB 2015, by dwelling age

Quantification by dwelling age	pre 1919	1919 to 1944	1945 to 1964	1965 to 1974	1975 to 1980	1981 to 1990	Post 1990	All dwelling ages
Estimated total number (000s)	316 - 385	338 - 410	336 - 408	217 - 276	63 - 96	71 - 106	133 - 180	1,594 - 1,742
Number with insulation potential (000s)	219 - 278	242 - 303	204 - 260	141 - 189	47 - 76	48 - 78	50 - 80	1,046 - 1,168

7.2.2 Flat roofs

Table 67 – Estimated number of flat roof dwellings, and the cost and carbon saving potential of these in GB 2015, by dwelling type

Quantification by dwelling type	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	All dwelling types
Estimated total number (000s)	7 - 21	25 - 47	21 - 42	54 - 85	181 - 234	22 - 44	354 - 428
Number with insulation potential (000s)	6 - 20	6 - 19	16 - 35	32 - 57	137 - 184	12 - 29	247 - 308
Cost to insulate all dwellings (£m)	£10.3 - £32.4	£12.0 - £38.2	£17.3 - £37.5	£33.9 - £60.4	£225.6 - £303.2	£16.2 - £38.7	£315.3 - £510.3
Typical cost per dwelling	£1,640	£1,960	£1,060	£1,060	£1,640	£1,320	£1060 - £1960
Carbon saving potential from all dwellings (kTCO_2 / yr)	9.1 - 28.8	7.6 - 24.3	11.4 - 24.7	22.3 - 39.7	200.3 - 269.2	10.0 - 23.8	260.7 - 410.6
Average CO_2 saving per home (TCO_2/yr)	1.46	1.25	0.70	0.70	1.46	0.81	1.21

Table 68 – Estimated number of flat roof dwellings in GB 2015, by dwelling age

Quantification by dwelling age	pre 1919	1919 to 1944	1945 to 1964	1965 to 1974	1975 to 1980	1981 to 1990	Post 1990	All dwelling ages
Estimated total number (000s)	28 - 52	30 - 54	77 - 113	109 - 152	27 - 51	9 - 24	18 - 38	354 - 428
Number with insulation potential (000s)	14 - 32	26 - 49	60 - 92	82 - 119	24 - 46	0	1 - 10	247 - 308

7.2.3 Room-in-roof

Table 69 – Estimated number of room-in-roof dwellings, and the cost and carbon saving potential of these in GB 2015, by dwelling type

Quantification by dwelling type	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	All dwelling types
Estimated total number (000s)	26 - 49	314 - 384	89 - 127	309 - 378	19 - 39	400 - 477	1,240 - 1,371
Number with insulation potential (000s)	13 - 30	143 - 191	32 - 57	145 - 193	8 - 22	200 - 256	599 - 692
Cost to insulate all dwellings (£m)	£20.7 - £48.5	£322.0 - £430.2	£34.5 - £61.1	£154.1 - £205.7	£12.1 - £35.1	£250.0 - £320.2	£793.3 - £1,100.8
Typical cost per dwelling	£1,610	£2,250	£1,070	£1,070	£1,610	£1,250	£1070 - £2250
Carbon saving potential from all dwellings (kTCO_2 / yr)	17.9 - 42.0	200.6 - 268.0	22.3 - 39.6	101.3 - 135.2	10.5 - 30.3	154.2 - 197.4	506.6 - 712.5
Average CO_2 saving per home (TCO_2/yr)	1.39	1.40	0.69	0.70	1.39	0.77	0.94

Table 70 – Estimated number of room-in-roof dwellings in GB 2015, by dwelling age

Quantification by dwelling age	pre 1919	1919 to 1944	1945 to 1964	1965 to 1974	1975 to 1980	1981 to 1990	Post 1990	All dwelling ages
Estimated total number (000s)	512 - 599	306 - 374	191 - 245	67 - 101	18 - 38	24 - 46	33 - 58	1,240 - 1,371
Number with insulation potential (000s)	238 - 299	144 - 192	107 - 149	36 - 62	9 - 25	4 - 15	1 - 9	599 - 692

7.2.4 Mansard roofs

Table 71 – Estimated number of mansard roof dwellings, and the cost and carbon saving potential of these in GB 2015, by dwelling type

Quantification by dwelling type	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	All dwelling types
Estimated total number (000s)	11 - 27	9 - 24	4 - 15	10 - 26	18 - 38	21 - 42	101 - 142
Number with insulation potential (000s)	10 - 25	2 - 13	0 - 7	5 - 17	7 - 21	8 - 23	53 - 84
Cost to insulate all dwellings (£m)	£19.3 - £50.7	£8.6 - £44.8	£0.0 - £10.9	£6.2 - £22.7	£14.2 - £42.5	£15.2 - £42.8	£63.5 - £214.4
Typical cost per dwelling	£2,020	£3,510	£1,640	£1,360	£2,020	£1,890	£1360 - £3510
Carbon saving potential from all dwellings (kTCO_2 / yr)	12.9 - 33.7	3.7 - 19.4	0.0 - 4.9	3.0 - 10.9	9.5 - 28.2	6.5 - 18.3	35.5 - 115.5
Average CO_2 saving per home (TCO_2/yr)	1.34	1.52	0.73	0.65	1.34	0.81	1.10

Table 72 – Estimated number of mansard roof dwellings in GB 2015, by dwelling age

Quantification by dwelling age	pre 1919	1919 to 1944	1945 to 1964	1965 to 1974	1975 to 1980	1981 to 1990	Post 1990	All dwelling ages
Estimated total number (000s)	26 - 49	7 - 21	22 - 44	4 - 16	1 - 9	4 - 15	6 - 20	101 - 142
Number with insulation potential (000s)	17 - 37	4 - 16	9 - 24	1 - 10	0 - 8	1 - 9	0 - 2	53 - 84

7.2.5 Chalet roofs

Table 73 – Estimated number of chalet roof dwellings, and the cost and carbon saving potential of these in GB 2015, by dwelling type

Quantification by dwelling type	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	All dwelling types
Estimated total number (000s)	0 - 3	121 - 165	0 - 7	3 - 14	0 - 3	111 - 154	258 - 321
Number with insulation potential (000s)	0	61 - 93	0	0 - 5	0	49 - 79	121 - 166
Cost to insulate all dwellings (£m)	-	£127.5 - £196.3	-	£0.0 - £5.2	-	£56.2 - £90.3	£183.6 - £291.8
Typical cost per dwelling	£1,470	£2,110	£960	£960	£1,470	£1,140	£960 - £2110
Carbon saving potential from all dwellings (kTCO_2 / yr)	-	89.0 - 137.1	-	0.0 - 3.9	-	39.4 - 63.3	128.3 - 204.3
Average CO_2 saving per home (TCO_2/yr)	1.46	1.47	0.71	0.71	1.46	0.80	1.16

Table 74 – Estimated number of chalet roof dwellings in GB 2015, by dwelling age

Quantification by dwelling age	pre 1919	1919 to 1944	1945 to 1964	1965 to 1974	1975 to 1980	1981 to 1990	Post 1990	All dwelling ages
Estimated total number (000s)	7 - 20	14 - 32	52 - 83	97 - 137	10 - 26	11 - 28	20 - 40	258 - 321
Number with insulation potential (000s)	2 - 11	6 - 20	23 - 45	47 - 76	6 - 19	2 - 12	3 - 13	121 - 166

7.2.6 Roof faults

As identified in Section 5.1 there are a number of potential roof issues which may need to be addressed in order for the loft of a dwelling to be effectively insulated. In this section we present results from analysis of the rate of roof structural and covering faults reported to the EHS, to highlight the prevalence of these problems; this is assumed to be representative of GB.

We have not quantified in this report the cost of addressing these faults. This is likely to vary substantially on a dwelling-by-dwelling basis and site specific assessment, particularly in the case of structural weaknesses, is necessary.

Table 75 – Definition of roof structural faults identified in EHS

Fault type	Category	Description
Roof structural (including sagging, humping, spreading)	Leave	No action required
	Strengthen	Structural fault, for example humping or sagging, which could be addressed by internal strengthening of roof structure.
	Replace	General unevenness or distortion indicative of underlying weakness in the roof structure, or spreading of roof at the eaves. Replacement of rotten or under-sized sections necessary.
Roof covering	Leave	No action required
	Isolated repairs	Repair to localised damage, for example missing, broken or slipped tiles, a hole in the fabric cover, or isolated defects.
	Renew	Replacement of roof covering required, for example where there is deterioration or slippage of the fabric cover, cracking or severe blistering.

Since this does not form part of the main quantification in this report, it was appropriate to use the most recently available data (EHS 2013-14). The outputs are a breakdown of the estimated number of dwellings identified as having the roof structural faults defined in Table 75, split by dwelling type (Table 76), dwelling age (Table 77), construction type (for structural faults, Table 78) and covering type (for covering faults, Table 79). Dwellings are defined as having a mixed roof construction or covering where no single construction type or covering extends over at least half of the roof area.

The key points to note from these estimates are that:

- Based on the prevalence of roof faults recorded in the EHS, we estimate that there are around 15% of dwellings in GB which may have some structural or covering fault affecting the roof.
- The prevalence of roof faults is higher in older dwellings – with more than one-in-five dwellings built before 1945 likely to have some form of fault.
- The majority of faults recorded in the EHS did not require replacement or renewal of roof elements, but would still require some remedial work to strengthen some part of the roof structure (66%), or repair some area of the roof covering (59%).

Table 76 – Estimated number of dwellings with a roof structural or covering fault in England, by dwelling type

Quantification by dwelling type	Converted Flat	Detached	End terrace	Mid terrace	Purpose built flat	Semi detached	All dwelling types
Total number of dwellings (000s)	918	5,253	2,417	4,371	3,847	6,421	23,226
Estimated % with a roof fault	22%	10%	17%	20%	8%	18%	15%
Estimated number with a fault (000s)	205	515	409	879	304	1,170	3,482
% all dwellings with roof spreading	3.3%	0.4%	2.3%	2.2%	0.3%	1.7%	1.4%
% all dwellings with roof humping	0.2%	0.1%	0.5%	0.1%	0.1%	0.3%	0.2%
% all dwellings with roof sagging	0.0%	0.1%	0.3%	0.2%	0.0%	0.2%	0.1%
% all dwellings with covering fault	20.2%	9.1%	14.6%	17.9%	7.8%	16.4%	13.6%
% all dwellings with structural fault	4.1%	1.7%	3.8%	3.7%	0.7%	2.9%	2.6%

Table 77 – Estimated number of dwellings with a roof structural or covering fault in England, by dwelling age

Quantification by dwelling age	pre 1919	1919 to 1944	1945 to 1964	1965 to 1974	1975 to 1980	1981 to 1990	Post 1990	All dwelling ages
Total number of dwellings (000s)	4,626	3,930	4,506	3,244	1,512	1,953	3,455	23,226
Estimated % with a roof fault	28%	28%	14%	7%	6%	3%	2%	15%
Estimated number with a fault (000s)	1,293	1,105	647	217	87	54	79	3,482
% all dwellings with roof spreading	4.2%	2.2%	0.6%	0.3%	0.0%	0.2%	0.1%	1.4%
% all dwellings with roof humping	0.3%	0.4%	0.1%	0.1%	0.0%	0.1%	0.0%	0.2%
% all dwellings with roof sagging	0.5%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%
% all dwellings with covering fault	24.6%	26.1%	13.5%	5.9%	4.8%	2.3%	2.2%	13.6%
% all dwellings with structural fault	6.5%	4.0%	1.5%	1.2%	1.0%	0.4%	0.1%	2.6%

Table 78 – Estimated number dwellings with roof structural fault in England, by roof construction type

Quantification by dwelling age	Pitched	Flat	Mansard	Chalet	Mixed	All construction types
Total number of dwellings	21,158	1,225	144	318	381	23,226
Estimated % with a structural fault	2.7%	0.5%	0.0%	1.1%	5.4%	2.6%
Estimated number with a structural fault	564	6	-	3	21	594
% which do not require any action	24%	0%	-	0%	41%	24%
*% which require some area to be strengthened**	67%	22%	-	100%	59%	66%
% which require some area to be replaced	9%	78%	-	0%	0%	9%

* which do not require any area to be replaced

Table 79 – Estimated number dwellings with roof covering fault in England, by roof covering type

Quantification by dwelling age	Asphalt	Clay tile	Concrete tile	Felt	Glass/ metal/ laminate	Man-made slate	Natural covering*	Mixed	All covering type
Total number of dwellings	662	3,656	13,426	453	354	1,287	2,740	648	23,226
Estimated % with a covering fault	5.0%	28.6%	6.8%	7.4%	4.9%	9.0%	32.0%	18.4%	13.6%
Estimated number with a structural fault	33	1,045	910	34	18	116	876	120	3,151
% which do not require any action	30%	32%	38%	8%	23%	20%	28%	26%	32%
*% which require some areas to be repaired***	54%	59%	53%	55%	77%	64%	63%	62%	59%
% which require some area to be renewed	16%	8%	9%	37%	0%	16%	9%	12%	9%

* slate/stone/shingle/thatch

* which do not require any area to be renewed

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9 Appendices

9.1 Appendix 1: List of respondents to stakeholder survey

Table 80 – List of respondents to stakeholder survey

Type	Organisation	Contact name
Installer	Aran Services Ltd	Kaz Morris
Local Authority	Ashfield District Council	Andrew Jackson
Professional body / other	British Board of Agrement (BBA)	Geoff Chambers
Local Authority	Blackburn with Darwen Borough Council	Stuart Pye
Housing Association	Boston Mayflower Ltd	Hadrian Asher
Local Authority	Bracknell Forest Council	Hazel Hill
Supplier	British Gas	Urszula Thorpe
Professional body / other	Bufca	John Bullen
Local Authority	Calderdale Metropolitan Borough Council	David Holder
Housing Association	Coast & Country	Mark Freeman
Professional body / other	Construction Products Association	Peter Caplehorn
Housing Association	Cornwall Housing Ltd	Brett Higham
Expert / researcher	Consultant - Hard to treat homes	Mervyn Kirk
Supplier	EDF Energy	Derek Mann
Other	en-form	Andrew Wilkinson
Manufacturer	Foamseal Ltd	Paul Denham
Research expert	Glasgow Caledonian University	Christopher Hugh Sanders
Professional body / other	Insulated Render and Cladding Association (INCA)	Ben Edmondson
Manufacturer	Knauf Insulation	Steve Duke
Local Authority	Leeds City Council	Sandy Rutherford
Supplier	npower	Bob Jackson
Professional body / Other	Property Care Association	Stephen Hodgson
Local Authority	Seton Council	David Colbourne
Housing Association	Scottish Federation of Housing Associations	David Stewart
Local Authority	South Kesteven District Council	Duncan Lucas
Local Authority	South Lakeland District Council	Daniel Russell
Professional body / Other	Stroma Certification Ltd	Andrew Parkin
Installer	The InstaGroup	Terry Evans
Manufacturer	ThermaBead Ltd	John Szymik

9.2 Appendix 2: List of attendees at stakeholder workshop

Table 81 – List of attendees at stakeholder workshop

Type of respondent	Organisation	Contact name
Installer	Avalon	Emma Adams
Installer	Avalon	Warren Reeder
Local Authority	Blackburn with Darwen	Stuart Pye
Local Authority	Bracknell Forest Council	Hazel Hill
Research / expert	Cambridge Architectural Research	Nicola Terry
Other professional body	CIGA	Ray Smart
Research / expert	Consultant	Mervyn Kirk
Research / expert	DECC	Yehuda Lethbridge
Installer	Dyson Energy Services	Lee Davies
Research / expert	EST	Brian Horne
Research / expert	EST	Greg Shreeve
Research / expert	EST	Joe Payne
Manufacturer	Foamseal	Paul Denham
Manufacturer	Isothane	Richard Spencer
Manufacturer	Knauf Insulation	Steven Heath
Local Authority	Leeds City Council	Sandy Rutherford
Research / expert	Loughborough University	Stephen Porritt
Other professional body	Ofgem	Claire Valente
Other professional body	RICS	Graham Ellis
Research / expert	Sustainable Home Survey Company	Agnes Czako
Installer	Wilmott Dixon	David Adams

9.3 Appendix 3: Common modelling assumptions for quantifying potential carbon impact

Table 82 - Heating system assumptions of modelled dwelling archetypes

Heating fuel	Heating system efficiency	Fuel carbon factor (kg CO_2 / kWh)
Gas	82%	0.185
Oil	86%	0.245
Electricity	100%	0.490
Solid fuel (coal)	60%	0.296

Table 83 - Average fuel mix for each dwelling type

Fuel type	Detached bungalow	Detache d house	End terrace	Ground floor flat	Mid floor flat	Mid terrace	Semi - detached bungalow	Semi-detached house	Top floor flat
Gas	82%	82%	90%	72%	72%	92%	89%	89%	72%
Electricity	3%	3%	7%	28%	28%	6%	6%	6%	28%
Oil	14%	14%	2%	0%	0%	1%	4%	4%	0%
Solid fuel	1%	1%	1%	0%	0%	1%	1%	1%	0%

Table 84 – Dimensions of modelled property archetypes

Dwelling Type	Total floor area (m^2)
Detached bungalow	67.3
Detached house	148.6
End terraced house	78.8
Mid terraced house	78.8
Semi-detached bungalow	63.5
Semi-detached house	88.8
Top floor flat	60.9

9.4 Appendix 4: Estimates of cavity walls

9.4.1 DECC estimates of the number of fillable and unfillable cavity walls in Great Britain.

DECC's present estimations of cavity wall insulation are based on a 2008 baseline, taken from the housing surveys in England, Scotland and Wales. Records of all subsequent installations are taken away from this baseline, plus the addition of new-build properties (which are assumed to be insulated with no potential).

Cavity walls are categorised into one of the following categories.

- Insulated;
- Insulated or meets equivalent standard;
- Uncertainty;
- Limited potential; and
- Not insulated.

The definition of these categories and the method to quantify these are as follows:

Insulated: All homes recorded as having cavity wall insulation in the housing survey fall into this category. DECC assume that an additional 5% of the number of homes recorded as insulated, are also insulated. This is to account for homes that have been built with insulated walls, which would appear on the property survey as insulated[44].

Insulated or meets equivalent standard: These are homes with walls built after 1995 (or 1991 in Scotland). DECC assume that the thermal performance of the walls of these homes is greater than 0.45 W/m^2K thanks to building regulations during this period, and so there is no potential for wall insulation.

Uncertainty: These are homes with a cavity wall where it is uncertain whether the walls are insulated or not. DECC estimate the number of uncertain walls as equal to 5%[45] of homes recorded as insulated in the housing survey.

Limited potential: These are homes assumed to have walls that are not up to the thermal performance of current building regulations, but have a thermal performance close to current standards and therefore savings from additional insulation would be very small. These would include homes with partially filled cavity walls. DECC assumes that all homes recorded as having uninsulated cavities in the housing surveys built between 1983 and 1995 (or 1984 and 1991 in Scotland) fall into this category.

Not insulated: These are all cavity wall properties built before 1983 (1984 in Scotland) recorded as uninsulated minus a number equivalent to 10% of the number of homes recorded as insulated. This 10%

[44] This is because the property surveys do not undertake boroscope inspections and therefore will not identify insulation in certain properties where evidence of insulation is not visible from external inspection. The 5% assumption is based on a recommendation given to DECC by BRE.

[45] 5% based on recommendation given to DECC by BRE.

accounts for the 5% included in the uncertain category and an additional 5% added to the insulated category.

9.4.2 DECC's approach to estimating number of cavity walls versus this report's approach.

One of the key differences in approach is how underreporting of cavity wall insulation in the housing survey is dealt with (see 4.1.2 Stage 2. Number of uninsulated cavities modified to account for under-reporting of insulated cavity walls).

As detailed above DECC assume an additional 5% of properties recorded as insulated on housing surveys (pre-1996 in England and Wales, pre-1992 in Scotland) are insulated and an additional 5% are uncertain. This estimation is based on a reporting recommendation from BRE.

Upon starting this analysis EST have gained access to the NHBC data which gives an indication of the proportion of new builds by year in GB that have been built with and without cavity wall insulation installed (see Table 10).

Instead of using the DECC assumption to include an additional 5-10% of insulated properties to account for housing surveys not recording as built insulations, in this analysis we have chosen to use the NHBC evidence base to estimate what proportion of homes recorded as unfilled have empty cavities.

NHBC holds registers for warranty for about 80 per cent of new homes. It contains records for around 4.1 million homes built since 1986. This data is based on returns from NHBC's building inspectors, and cannot be guaranteed to be 100 per cent accurate due to an inspector's limited ability to see the insulation in place for each property developed. Nonetheless this data set was the best source of data that could be identified for estimating the proportion of dwellings uninsulated as built.