UNIVERSITY COLLEGE LONDON (UCL)
BARTLETT SCHOOL OF ENVIRONMENT, ENERGY AND RESOURCES (BSEER)

Establishing 'state-of-the-art' practice in the deployment of solid-wall insulation on UK Buildings

Understanding Best Practice in Deploying External Solid-Wall Insulation in the UK

Cambridge Architectural Research Ltd

Executive Summary

The roll-out of External Wall Insulation to solid walls can bring about significant emissions reductions from the building sector and make a significant impact on household energy consumption. However recent reviews commissioned by the Government have shown that there are technical problems with some installations that have led to subsequent performance issues.

Mass deployment and roll-out of energy efficient retrofit through area-based approaches has been increasingly seen to be a key method to delivering high quality and cost-effective installations. In this context of area-based approaches, we have studied mass deployment 'exemplar' housing retrofit schemes in five different towns and cities across the UK to identify, analyse and assess Best-Practice lessons where learning from actions subsequently led to successful outcomes. Although the methods used to retrofit the homes across these projects differ, and different approaches have been used to minimise cost and ensure quality, some useful general findings can be drawn from across the projects.

Of particular interest to BEIS is that retrofit installation costs, varied between approximately £3,900 to over £12,000 for a single dwelling. Detailed EWI costing parameters for a subset of projects in Bristol (300 homes) suggest that a significant number of properties (as high as 50% in Bristol) were delivered for less than £7,000 per property. Projects included social housing and private rented properties as well as owner-occupied homes, where owner-occupier customer contributions ranged from £750 to £10,000 for installations.

Success Factors: Best-Practice as an enabler of quality and cost-effectiveness

Best-Practice is a key determinant of cost efficiency and examples of Best-Practice were often identified in cases where the installation of EWI was viewed not as a measure but as a construction project where appropriate management principles were applied in planning, resourcing and implementation. In spite of the limitations in measuring success and making comparisons between projects, this study has identified a range of EWI Best-Practice success factors, which are suggested to have contributed to maintaining quality, and where possible, minimising costs. The following findings appear to be broadly true across the five projects:

- The costs of retrofitting a large number of properties through area-based and a street-by-street approaches are significantly lower than the costs of retrofitting properties individually, where the average cost for all projects was roughly 45% lower than the Energy Saving Trust's average cost estimate of standalone EWI installation. These approaches simplify the design and construction process and are therefore key in achieving cost effectiveness through enabling better procurement and deployment.

- Key areas where significant cost savings can be made when applying economies of scale include fixed costs such as administration, process-based costs such as warehousing and stock-holding and enabling works such as scaffolding. Representatives from national-scale construction companies noted that the main areas of cost-savings include efficient use of scaffolding which contributed up to 25% of the total costs (especially on blocks of flats), while material costs were relatively fixed.

- Despite the relatively high costs involved, project participants across all case studies viewed that cost in itself was not the main barrier to EWI deployment. When cost is viewed in the context of a more complex customer value proposition (as interpreted by the customer), the perceived value of EWI (e.g. 'better, greener, warmer' homes) was considered to outweigh cost issues. This was especially true given the total value of the work that was carried out and the interest-free loans available to cover customer contributions (typically 25% of total cost). In considering this beyond the current grant-based funding environment, this suggests that a simple and effective value proposition for potential customers that clearly communicates the value of EWI as well as the financial offering and/or contribution was a key aspect in recruiting and retaining customers.

- The provision of standard specification for material and installation, where feasible, provides scope for cost reduction at scale, particularly from a procurement and supply chain perspective. The production of standard client terms and conditions can save time, effort and costs.

- Across projects, a number of key roles in recruiting potential customers as well providing valuable technical support, were identified. This included the Retrofit Co-ordinator/Smart Advisor role to provide consumer-facing independent technical oversight and cost auditing of contractor quotes. Although this involved an estimated upfront cost of £200-£300 per property, in one case this led to the revision of a quote over 120% the average installation cost. Community Energy Partnerships were also identified as pivotal in the engagement and recruitment of residents for EWI schemes at community scale to help support area- based delivery.

- Ensuring quality involves de-risking installation through inspection regimes and enabling works, such as structural repairs. These often drive up costs (up to 5-10% of the project costs in Slough) but are necessary to implement as a failure avoidance measure. It is however not straightforward to maintain quality, where remedial works had to be carried out in three out of the five projects and incurred significant costs for the Bristol GDC project in particular. To maintain quality, project participants suggested that a more holistic and sustainable 'best value' approach using a more long term lifecycle to evaluating cost efficiency as a metric needs to be considered.

Challenges: Key Barriers to Delivery

Despite the clear need for EWI, some of the key challenges experienced in the delivery of mass roll-out projects in the UK were identified. These included a number of technical and non-technical barriers that have contributed to relatively limited uptake and, have subsequently, impacted the ability to achieve cost effectiveness:

- ***Technical barriers*** to the widespread uptake of EWI can drive up costs. These are mainly associated with bespoke detailing and remedial works required for homes, particularly where properties have been altered since construction or where existing problems need to be addressed. Increasing U-Value requirements for EWI installation performance (often referred to as 'chasing U-Values') might not be financially feasible in some cases. For example, increased EWI thicknesses required to achieve a certain U-Value target might involve cost increases for structural reinforcement and detailing and may result in property access constraints. In addition, the current view that EWI was a low-skilled process has resulted in a transient workforce with inadequate skills and subsequent poor quality installation practices that have a long-term impact on cost.

- ***Non-technical issues*** which drive up costs include constraints and variability of planning requirements, due the ambiguousness of what constitutes 'permitted development'. Furthermore, avoiding the 'pepper pot' approach in deployment is often difficult due to variable consumer decision making timelines and conflicting priorities. For the reviewed projects, the short term funding available for implementation was not conducive to sustaining the market, maintaining job security and retaining the knowledge and resources within the contractors and the councils themselves.

Table of Contents

List of Abbreviations and Terms

BBA	British Board of Agrément - A UK body issuing certificates for construction products and systems and providing inspection services in support of their designers and installers
BCC	Bristol City Council
BISF	British Iron and Steel Federation (House)
CEP	Community Energy Program
CERT	Carbon Emissions Reduction Target
CESP	Community Energy Saving Programme
HTT	Hard To Treat
IWI	Internal Wall Insulation
ECO	Energy Company Obligation
EPC	Energy Performance Certificate – An 'asset' rating of energy efficiency of buildings from A (most efficient) to G (least efficient)
EWI	External Wall Insulation
GDC	Green Deal Communities Program
GDHIF	Green Deal Home Improvement Fund- A Government scheme providing loans for home improvement for owner occupiers
GMCA	Greater Manchester Combined Authority
LA	Local Authority
PAS 2030	Publicly Available Specification- A standard to be adhered to for installing Energy Efficiency Measures (EEM) under schemes such as ECO.
PRS	Private Rented Sector
RSL	Registered Social Landlord
SWI	Solid Wall Insulation

1. Introduction: The Insulation of Solid Wall Properties the UK Housing Stock

The widespread use of solid wall brick construction came with the onset of the Industrial Revolution in 18th and 19th centuries. During this era, solid wall construction (typically 9 inch or 230mm thick or greater, brick or stone walls) increased in popularity and was the predominant construction method for the large number of terraced properties built to meet the demand for housing caused by the mass migration of workers into urban areas (Beaumont, 2007). Solid walls continued to be the most common construction approach for the domestic sector until the housing boom of the 1920s and 1930s where construction shifted to cavity walls as a means of reducing both damp problems and construction costs (Beaumont, 2007).

Today, the existing UK residential stock consists of approximately 26 million homes, of which some 8 million have solid walls. It is estimated that 70% of these solid wall domestic properties have walls that are 9 inches thick and therefore offer very poor thermal performance (DCLG, 2008). As a consequence, solid wall properties are in general considered to be one of the four categories highlighted as ‘Hard to Treat’ (HTT) homes. HTT homes are defined by the Energy Saving Trust (BRE, 2008) as ‘homes that, for a variety of reasons, cannot accommodate 'staple' energy efficiency measures offered under schemes such as Warm Front in England’. In other words, these are properties that cannot easily and cost-effectively be improved by conventional measures such as wall or loft insulation and gas central heating (Dowson et al., 2012).

HTT homes comprise of 43% of the total UK stock, amounting to around 9.2 million properties. Of these, solid wall dwellings alone constitute an estimated 72% of the HTT stock (Vadodaria et al., 2010). It is estimated that under the specified SAP heating regime (**Table 1**), the HTT stock emits ~62 million tonnes of carbon dioxide (MtCO_2) per annum. This constitutes around 50% of the total stock emissions of ~123 MtCO_2. Of these, the total emissions from solid wall subtypes are estimated to be 44.8 MtCO_2 and contribute to the largest share (over 70%) (DCLG, 2008).

Table 1 Notional CO_2 emissions of housing stock with Hard to Treat subtype breakdown Source (BRE, 2008)

	Mean annual CO_2 emissions (tCO_2)	**No. of dwellings (000s)**	**Total annual CO_2 emissions (Mt CO_2)**
All stock	5.7	21,549	122.9
Not Hard to Treat	4.9	12,324	59.9
Hard to Treat (subtype breakdown below)	6.7	9,206	62.0
Solid Wall	6.2	5,035	31.21
Off gas network	7.0	1,671	11.63
Solid Wall and Off gas network	11.8	731	8.62
No Loft	5.6	644	3.58
Solid Wall and No Loft	6.8	569	3.88
Off gas and No Loft	7.1	122	0.86
Solid Wall, Off gas and No Loft	10.0	109	1.09
High Rise	3.5	326	1.13

1.1 External Solid Wall Insulation: The Retrofit Challenge

The insulation of solid walls can bring about significant emissions reductions from the building sector, make a significant impact on household energy consumption (see **Table 6** for reduction estimates) and play a large part in tackling fuel poverty (Changeworks, 2012). It is also vital to enabling the roll-out of heat pumps (IPPR, 2011).

The scale of the retrofit required to achieve this is significant. In addition to the 8 million UK homes that have solid walls, a further 4.3 million are 'hard-to-treat' cavity construction which are more suitable for EWI rather than cavity insulation. Taken together - not discounting the relatively small number unsuitable for EWI (e.g. heritage properties, homes with unsuitable construction or in extreme environmental exposures) - this leaves roughly 11 million homes with the potential for EWI retrofit (DECC, 2014). These include 23% of the 12 most common UK domestic property archetypes (around 60% of the total stock) and 90% of HTT converted flats (**Figure 1**), highlighted by an analysis of the English Housing Stock 2008 as prime candidates for EWI (Hansford, 2015 & CSE 2011).

The application of EWI in the UK was very limited prior to 2008 and remains low. Government statistics issued by BEIS (previously DECC) indicate that the total number of EWI installations currently stands at 280,000 (Forman, 2015). Recent figures suggest that 30,000 installations were undertaken in 2016 - a decrease from the peak levels of around 50,000 per annum recorded in 2014 (BEIS, 2017a). While this indicates that significant improvements have been made in previous years, this remains well below the CCC trajectory of 200,000 required to reach carbon reduction targets (**Figure 2**) and means that around 95% of the potential stock available for EWI measures has yet to be insulated (CCC, 2010 & Forman, 2015).

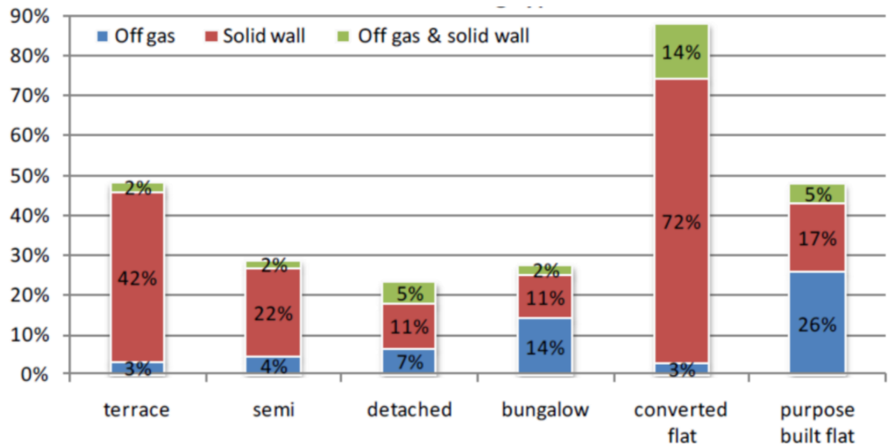


Figure 1 Distribution of solid wall house types in HTT stock. Source: CSE 2011

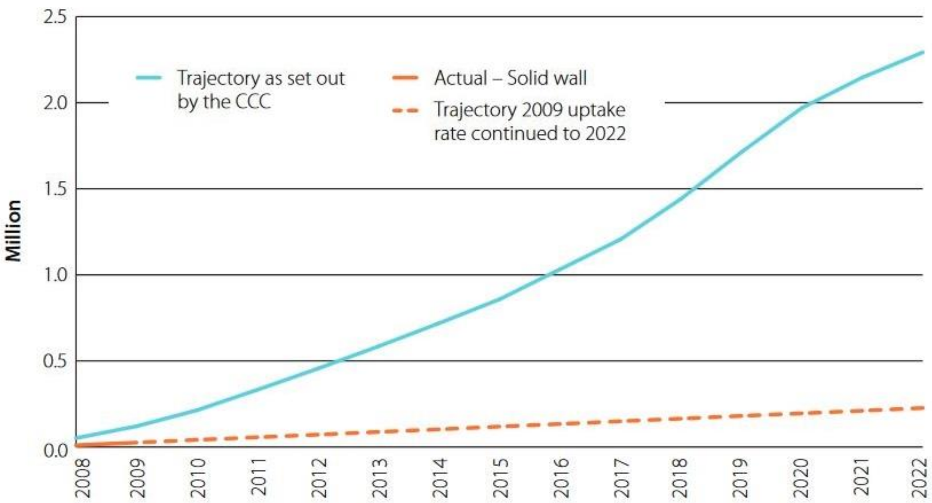


Figure 2 Cumulative installations of SWI (2008-2022). Source: CCC, 2010

1.2 Barriers to EWI Deployment

Despite the clear need for External Solid Wall Insulation (EWI), demand remains largely depressed. Both the Hansford (2015) and Directorate (2016) reports, supported by literature in this field, suggest that a number of technical and non-technical barriers that have contributed to relatively limited uptake (**Table 2**).

Table 2 Technical and non-technical barriers to EWI deployment

Technical Barriers		Description	Sources
Applicability limitations	Dwelling type	Application restrictions to properties where external appearance needs to be retained e.g. in listed buildings & conservation areas. EWI is generally unsuitable in multi-occupancy buildings unless carried out on all properties to create a uniform appearance & wall depth.	Heath, 2014
	Structure	Application restrictions to properties with insufficient structural support to take insulation weight (traditional buildings & non-traditional construction).	Heath, 2014
	Location	Properties in exposed climates & remote areas are challenging as transporting heavy construction materials & finding the installation skills & specialist products required might be difficult.	Changeworks, 2012
	Systems	Applying damp a proof course means that homes with EWI will not always be suitable for low temperature heating.	NCH, 2016a
	Timing	Restrictions on when work can be carried out, e.g. due to weather & rain.	AECB, 2011
Technology	Bespoke detailing	EWI requires a high degree of bespoke design due to the heterogeneity & complexity of homes	Atkinson, 2015
	Limited products	The currently available range of specialist products for specific detailing is inadequate & costly.	Baker, 2013
	Poor quality management	Installation involves a system of poor production quality. The few controls on installation that exist are frequently inadequate & the alignment of support to improve it remains weak.	Forman, 2015
Supply chain/ skills	Limited capacity	Insulation installers have highlighted concerns regarding EWI installation capacity in the UK, where there may not be enough installers to meet potential demand.	ETI, 2012
	Lack of skills	There is a shortage of specialist skills & training. This is especially true for many properties where specialist solutions are required.	Patterson, 2012
Non-Technical		Description	Sources
Financial	High upfront costs/long payback period	Costs vary, but generally involve high upfront and fixed costs (specification, logistics & set-up). Delivery to an individual property in a customer-driven model are prohibitively high in the short to medium term.	Changeworks, 2012 & AECB 2011,
	Inadequate finance options	EWI was effectively un-financeable under the Green Deal 'Golden Rule' market based mechanism for the private sector.	Gillich, 2017
Consumer/Occupant	Lack of uptake	Household awareness of EWI as an improvement measure is very limited. Consumer engagement requires significant effort & expenditure	EST, 2009 & ETI, 2012
	Poor perception	This is mainly due to numerous examples of poor installation & workmanship & may lead to lack of uptake of for fear of damaging properties.	Roberts, 2008 & NCH, 2016a
	Occupant permission	Permissions are needed from multiple tenants & owners in multi-tenure block & social housing, in particular where households in a block could refuse works or contribution to the cost of measures.	AECB 2011
	Disruption	During installation (possibly including moving out temporarily) & other changes required to property.	AECB, 2011
Regulations	Inconsistent policy	Variable & short-term policies do not allow adequate time for proper planning/implementation. Resultant loss of experienced individuals within Local Authorities & social housing providers.	Preston & Mallett,2017 & AECB, 2011
	Planning permissions	Inconsistent requirements from different planning authorities. Planning objections have prevented the installation of EWI in some projects, & increased delivery & set up costs for others.	AECB, 2011

Information	Limited stock information	Inadequate data has resulted in limitations on stock information needed to drive or assist with the delivery of measures.	AECB, 2011
	Lack of impartial advice	Difficulty in finding informed & unbiased consumer advice could prevent households proceeding with installation & may potentially lead to market paralysis. This is exacerbated where conflicting advice exists, with recommendations or notes of caution varying between sources.	Changeworks, 2012

1.3 The Need for Learning from Best-Practice

The term ***Best-Practice*** is one that is used across various economic activities including the building construction and management sector. In general, the term refers to the combination of the most successful elements of a set of policies, systems and procedures that, at any given time, are generally regarded by peers to be those that deliver the most effective or optimal outcome, such that they are considered as a benchmark worthy of wider adoption (BCA, 2008). It is useful to consider this concept in the wider context (**Figure 3Error! Reference source not found.**). Here Best-Practice knowledge underpins examples of excellence that go beyond ***Current Practice*** -the commonly practised policies and procedures that lead to the de facto level of performance, subsequently informing ***Future Practice*** by providing lessons that can be implemented as a key driver of quality improvement.

The UK housing stock is among the most inefficient in Europe, where the domestic sector represents around a quarter of UK total emissions. The majority of the current stock was constructed before thermal building regulations existed (Forman, 2015) and with a turnover of less than 1% per annum, at least 85 % of the homes that will be standing in 2050 have already been built (CIBSE, 2013). Consequently, domestic retrofit in particular represents one of the biggest employment and growth opportunities, where research suggests that an annual investment of £7billion will create up to 250,000 jobs by 2030 (UKGBC, 2013). To achieve this, a significant built environment industry transformation is required, where Best-Practice knowledge pertaining to new technologies and procurement and implementation methods is needed to create a compelling market opportunity for industry and model for future development (Lowe et al., 2012).

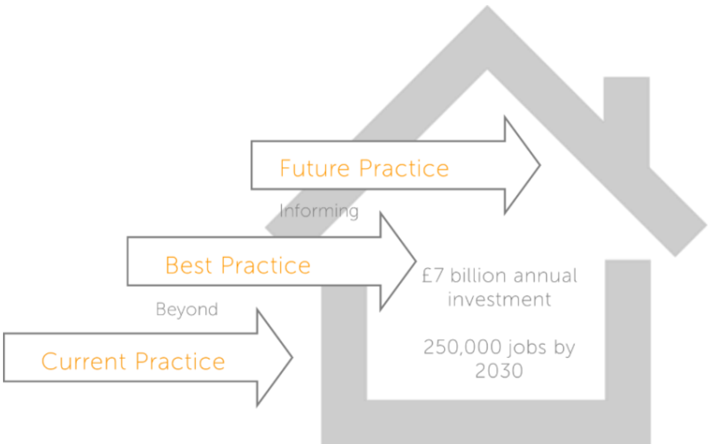


Figure 3 Current, best and future practice

Solid wall insulation was previously a priority for ECO funding and insulating solid wall homes is part of the UK Government's Carbon Plan. However, recent reviews commissioned by the Government have shown that there are technical problems with some installations that have led to subsequent performance issues (NCH, 2016a). Learning from Best-Practice can therefore provide a key opportunity to address these issues, where learning from actions that subsequently led to successful outcomes provides a key mechanism by which Best-Practice can be transferred and adopted (Innovate UK, 2011).

1.4 Study Aims and Approach

To address the need for Best-Practice knowledge, this study aims to establish ‘state-of-the-art’ practice in the deployment of solid-wall insulation in the UK by addressing the following research questions defined by BEIS:

1. How does the cost of SWI retrofits compare across different projects? How are these costs associated with retrofit quality?
2. What specific examples are there of EWI Best-Practice and are these likely to be repeatable?
3. What do local authorities or other project developers see as the barriers and drivers to more widespread EWI uptake?

The defined scope focuses specifically on the application of external wall insulation (EWI) in solid wall properties. Where relevant, to ensure inclusiveness, the work will include information obtained from projects where EWI was applied, but there is an uncertainty in regards to the wall construction type.

The rationale of our approach stems from the key challenges highlighted by our experience in investigating retrofit deployment practice. In particular, the limitations associated with the anecdotal nature of case study research which impacts the ability to transfer learning or generalise key lessons for wider application. Thus to address this, a wider body of evidence that might corroborate or challenge emerging views of what Best-Practice is, was analysed before engaging in the in-depth case study analysis.

1.5 Report Structure

The report is structured around a main theme focusing on ***understanding Best-Practice in deploying external solid-wall insulation in the UK*** and is organised as follows:

- **Section 1 Introduction** provides an overview of the report, summarising the aims, scope and overall approach of the work.
- **Section 2 Evidence Review: Defining ‘Best-Practice’** is an enabling rapid review of key evidence that objectively defines what is considered to be (i.e. to learn what comprises) ‘Best-Practice’ in EWI deployment. This includes highlighting what constitutes an ‘exemplar’ project, investigating the context of the application of Best-Practice in these exemplars and enabling the identification of the most robust approach to analysing and learning from them.
- **Section 3 Demonstrating ‘Best-Practice’** builds on the findings of the review and focuses on the analysis of a number of illustrative projects and develops targeted approaches to interrogating and analysing them. The section provides in-depth feedback on the drivers and barriers to achieving Best-Practice in a real-life context, highlighting the complex processes and interactions that underpin this.
- **Section 4 Findings and Conclusions** highlights the overall findings of the study and defines the key lessons across projects, where each case study is assessed in regards to how Best-Practice was applied, its impact on quality and cost effectiveness and, importantly, where barriers to implementation existed.

2. Defining Best-Practice in External Solid Wall Insulation: Findings from Existing Evidence

Rapid evidence reviews are an increasingly employed method in fields such as medical research where a swift rigorous analysis is required to provide a concise, focused examination of information related to a question of current interest or to inform practice and policy (Thomas, 2013).Within the context of this work, an enabling review of over 50 publications was undertaken to synthesize key findings on Best-Practice, with the aim to:

Firstly, objectively define what is considered to be (i.e. to learn what comprises) 'Best-Practice' in EWI deployment through an analysis of a wider body of evidence. The knowledge generated will corroborate or challenge emerging views of what Best-Practice before engaging an in-depth case study analysis and addresses the research questions by providing a broader view from a number of deployment projects.

Secondly, through the inclusion of a wider scope of EWI deployment projects, the review will help determine what constitutes an 'exemplar' project and enable the identification of the most robust approach to analysing and learning from those selected for analysis within the context of this work.

The methodology for undertaking this review is detailed in **Appendix A-1**. This is underpinned by the consideration of the integrated process described in Error! Reference source not found. that includes the key technical, supply chain, funding and customer based approaches (enablers) that have contributed to what can be defined as 'Best-Practice' in the deployment of external solid wall insulation as well as considering the potential associated unintended consequences and their underlying causes (risks). The key findings presented below are structured around each of these key themes. Where relevant, the work references specific projects identified in the literature reviewed to enable a better understanding of the practical context of each of the areas. A summary table of these key projects is included in **Appendix A-2** of this report.

Figure 4 Key factors associated with Best-Practice

2.1 Technical Approaches

The key findings and recommendations from this section are:

- Although technological advances have been made in the development and manufacturing of ‘future’ EWI materials, the majority in use today are either classed or Traditional (relatively low thermal conductivity) or State-of the Art (lowest thermal conductivity).
- The insulation installation industry in the UK is dominated by SMEs who subcontract to small and micro enterprises, often through ‘design-build’ contracts.
- The selection of appropriate materials and installation technique, is a key factor in the effectiveness of EWI systems, where specific materials may better suit certain property types or locations.
- Poor EWI installations can result not only in un-met performance targets, but also an increased risk of physical damage to the refurbished property as well as health and safety hazards.
- Installers should have appropriate levels of skill and understanding, and work within a system of effective training, certification and construction management.

External wall insulation (EWI) refers to all categories where insulation is affixed to the external surfaces of walls. EWI systems are built up from different layers of which an insulation material is the main component. This may be then finished with either render or cladding materials (Densley Tingley et al., 2015).

2.1.1. Types of Insulation and Installation Methods

The external solid wall insulation sector can be segmented into two specific product types (Wilkinson, 2008):

- Wet rendered: An insulation layer, plus a protective layer of render with decorative finish.
- Dry cladding systems: Dry cladding fixed to the outside of a building.

In regards to the materials used, Jelle (2011) identifies over 18 types that cover three main categories;

- Traditional: Common insulation materials with a relatively low thermal conductivity
- State-of the art: Materials and solutions which have the lowest thermal conductivity
- Future: Materials and solutions (including the application of nanotechnology) used to create high performance thermal insulation materials[1]

A subset of these materials are used in EWI systems. Although technological advances have been made in the development and manufacturing of ‘future’ insulation materials, the majority of those in use today belong to the first two categories. This range of materials varies in terms of in-use thermal performance, embodied environmental impact, firmness and resilience, internal structure, vapour permeability and moisture retention (Densley Tingley et al., 2015; Forman, 2015; Jelle, 2011):

- polyurethane foam (PUR), board or sprayed
- polyisocyanurate (PIR), board or sprayed
- phenolic /polyethylene foam
- cementitious foam
- natural materials
- glass fibre
- expanded or extruded polystyrene (EPS/XPS)
- mineral wool

While mineral wools are more commonly available and cost less, EPS or mineral wool boards, phenolic and PIR foam boards are the most widely used (cost comparisons detailed in **section 2.4.2**

1 In addition, this may include the use of innovative materials to lower costs while maintaining performance levels (e.g. Pacheco-Torgal, 2014; Zhou et al., 2010).

and **Table 7**). Natural materials are more expensive, as they are more vapour permeable, help reduce problems associated with damp and moisture and have lower environmental impact and embodied energy and are recyclable (Changeworks, 2012; Forman, 2015).

EWI can be installed over most forms of wall construction, including framed structures. The EWI installation systems can in themselves be classified as either (Malone, 2013):

- Non-structural: The majority of EWI systems are of this type and need to be fixed to load bearing fabric using mechanical hammer fixings or a 'belt and braces' approach to installation by both gluing and mechanically fixing boards to the external façade. Non-structural systems are inappropriate for use in crosswall construction[2] and medium to high-rise stock.
- Structural: Insulation is mechanically fixed to a support rail system that spans between structural columns. These are often used for non-traditional and high-rise buildings and are a cost effective method of extending the life of defective buildings.

2.1.2 Technical Best-Practice

The selection of EWI materials, systems and associated installation processes as well as the planning and implementation procedures can have significant impacts on the service life and performance of insulation materials. Some key aspects pertaining to technical good practice include:

The use of appropriate EWI materials and systems: Specific materials may better suit certain property types or locations and careful consideration should be given to properties with historic significance, listed status or structural challenges (Hansford, 2015; Raslan et al., 2012a). For example, a key lesson highlighted in the Beeches Estate retrofit project in West Wales (Project 1) was the use of a tailored EWI system specifically designed to meet the challenges of the wet windy climate of the location during the installation process and beyond. To minimise risk and avoid over-complication, the use of innovative and new technologies/materials should be balanced with those that are well known and familiar. Further considerations include the visual impact on property appearance and potential increase in the building footprint. Here a variety of finishes and colours can be used to avoid monotony and loss of street character and a thinner system can be used on walls to avoid issues of encroachment and access rights to passageways if required (ETI, 2012).

Careful planning of the installation process: This revolves around the integration of features such as windows, and gutters and the selection of appropriate systems and fixings. Installation stage vulnerabilities such as inappropriate storage of materials, improper surface preparation, failure to properly install or maintain sealants or occlusion layers, or failure of the wall substrate should be considered (Forman, 2015). Pre-installation planning should take into account site space limitations (especially when extensive scaffolding is needed) or exposure to extreme weather and conservation area locations. A clear project plan should identify aims for each phase and set a 'freeze date' for any major variations to avoid installation delays (Monetti, 2016). A Retrofit for the Future report (Project 11, describing 100 projects across the UK) has pointed out that employing an experienced team, familiar with local planning regulations will increase chances for a successful delivery.

Integrated installation approaches: Ideally, installation should take place alongside the replacement of related features to allow for full and simple installation. For example, for the most common external feature- windows- various issues such as the potential for flanking losses of the thermal insulation may occur if not properly installed. During installation, insulation needs to be returned into the rough opening and connected as closely as possible to the window frame, sills should be removed and products that are designed to accommodate such concerns should be used when feasible (Baker, 2013). In the UK, the National Insulation Association and the Heating and Hot water Industry Council

[2] Crosswall construction takes all the building loads from floors and roof on the gable walls. The front and rear facades of these properties are non-load bearing and therefore unsuitable for fixing a standard EWI system.

have developed industry-wide specification (available early 2017), which covers Best-Practice this area.

Informed decision-making in the selection of installation approaches: The majority of EWI system installers use mechanical hammer fixings alone. However, as a result of failures of mechanical fixings into concrete, a minority choose to adopt the belt and braces approach to installation. These failures particularly affect no-fines houses and occur due to such factors as the use of the wrong length/size of hammer fixings, operatives not using depth stops attached to their drills when drilling for hammer fixings (often punching straight through walls) and the length of hammer. Appropriate surveying/investigation techniques such as exposing patches of substrate before fixing has commenced allows for informed decision-making in regards to the required length for hammer fixings (Malone, 2013).

Appropriate training and site management: Installers should have appropriate levels of skill and understanding, and work within a system of effective training, certification and management. However, the insulation installation industry in the UK is dominated by SMEs who often subcontract to small and micro enterprises (often 'design-build' contracts). This has led to a highly fragmented EWI installation industry with generally immature management practices. While EWI system design can address pre-installation issues, ineffectual site management during installation will negate effective design (Forman, 2015; Malone, 2013). Examples for this are given in numerous EWI installations (e.g. Project 4), where poor finishing around windows and gutters allowed water to run down walls, penetrate behind the insulation or run inside the property.

2.2 Supply Chain and Deployment Practices

The key findings and recommendations from this section are:

- The thermal insulation sector consists of three main actors; large manufacturers, large to mid-size distributors and smaller/fragmented groups of suppliers and installers.
- Current analysis generally suggests that supply chains needed to support large scale retrofit remain largely 'underdeveloped', which may prevent the UK from retrofitting homes at the rate needed to achieve carbon reduction targets.
- In terms of delivery, the involvement of multiple organisations in the coordination and delivery of the same product, leads to fragmentation, a lack of communication, difficulty in sourcing and procuring products and ineffective processes.
- The 'whole-house' and 'area-by-area' / street-by-street approaches provide clear advantages to measure-by-measure or piece meal approaches as they support economies of scale and can reduce both the labour content together with eliminating waste within the supply chain.

Supply chains are essential components in every sector, providing the basic building blocks that allow the production and delivery of products and services. Construction is a sector dominated by single skill trades that are largely in short supply compared with demand (Monetti, 2016). Within this set-up, three types of organisations participate in the retrofit sub-sector today. This includes large specialist providers who deliver larger scale services directly to large home providers such as RSLs, large home improvement providers who specialise in heating, double glazing and insulation and smaller traders who may engage in mostly private-sector improvement work. With the introduction of the Green Deal, in addition to small- and medium-sized energy companies, many large high street names attempted to enter the market to deliver 'end-to-end' customer solutions (from surveys to installation). The thermal insulation sector more specifically consists of the following actors (Wilkinson, 2008):

- Manufacturers: These are larger organisations who may operate as multinational corporations. Approximately 80% of materials and components used in construction are sourced from UK facilities. Many of the big manufacturers specialise in particular insulation types and have their own distribution facilities and installation teams or operate via a countrywide network of appointed installers.

- Distributors: These supply installers directly or deal with housing associations and local authorities, and provide proprietary training to decorators or specialist installers. Many of the larger groups have regional distribution facilities. A range of smaller, independent, regional distributors have formed the Independent Insulation Distributors Association (IIDA) to improve their competitive standing, through a centralised purchasing facility allowing them to obtain bulk discounts and ensuring competitive prices.
- Suppliers/installers: These tend to be smaller, more fragmented organisations that may include SMEs and sole contractors or traders. Installers usually offer an advisory service to homeowners and provide information on regulatory requirements and regulatory issues.

Current analysis suggests that the supply chains needed to support large scale retrofit remain largely 'underdeveloped', which may prevent the UK from retrofitting homes at the rate needed to achieve carbon reduction targets. The Simplified Solid Wall Insulation works traditional supply chain (**Figure 5Error! Reference source not found.**) illustrates the complex interaction of the diverse set of actors involved. Multiple organisations are often directly involved with the coordination and delivery of the same product, which creates an opportunity for fragmentation, a lack of communication, difficulty in sourcing and procuring products and ineffective processes. Research suggests that to support the development of the supply chain, a significant development of skills will be need to support the amount of jobs that will need to be created. A scenario-based analysis of the employment effects of a large-scale deep building energy retrofit programme in Hungary, found that over between in terms of Full Time Equivalent (FTE) job creation, between 15,000 FTE and 42,000 FTE jobs would be created per year. The results also indicated that for every FTE unit lost in energy sector employment in that year, almost 30 jobs would be created in construction for the deep renovation scenarios (Ürge-Vorsatz et al., 2010).

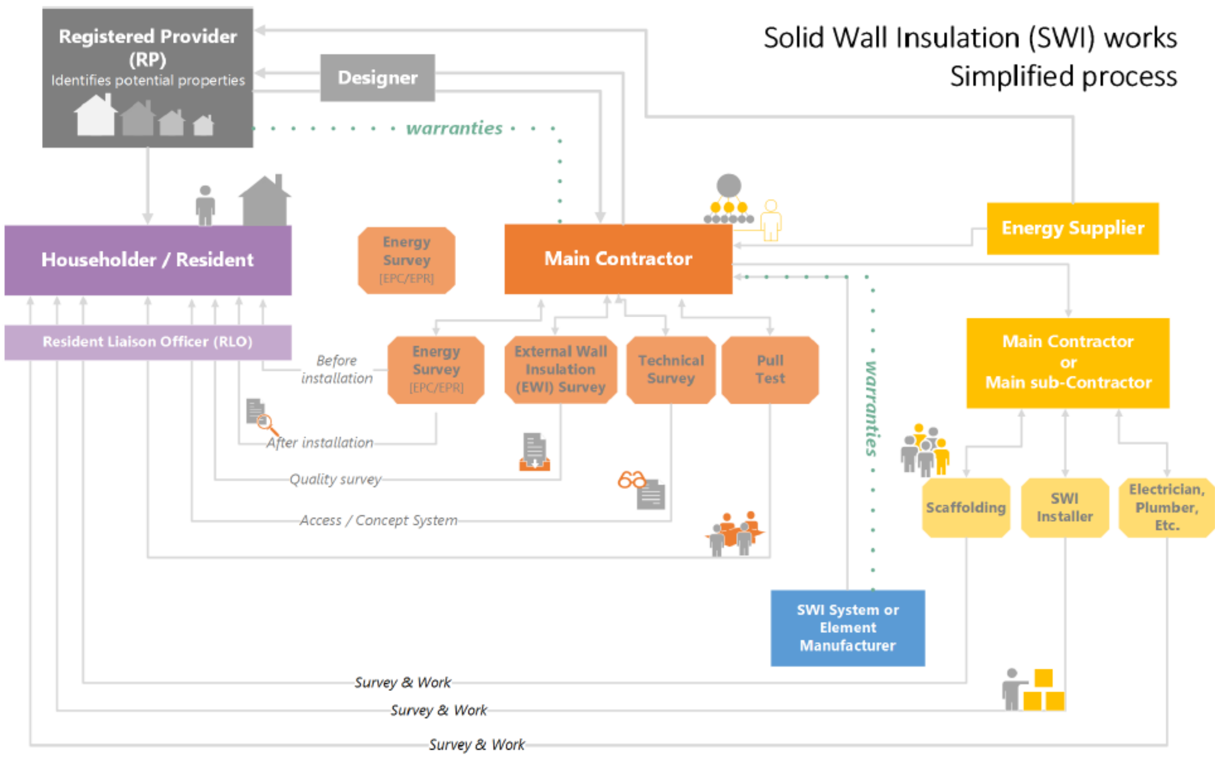


Figure 5 Solid Wall Insulation –Traditional Supply Chain process. Source: Monetti, 2016

2.2.1 Delivery and Deployment

Two dimensions can be used to describe the strategies employed for the delivery and deployment of EWI measures. The first is the house-scale retrofit approach, which describes the sequencing and extent of retrofit measures installed in each property (**Figure 6**). These can be categorised as:

1-Whole-House Retrofit: This approach involves the installation of several energy efficiency measures to the property during what can be considered a single project. This integrated approach allows for installation as a whole system, leading to more considered sequencing of works and appropriate sizing of systems which can generate greater benefits in terms of cost effectiveness, enhanced performance, risk and damage mitigation, reduced waste and disruption minimisation (ETI, 2012). To date, whole-house measures have typically been introduced as part of a major (architectural) refurbishment; rather than as interventions in their own right. Demand has typically stemmed from wealthy, energy conscious homeowners (particularly prevalent with historic buildings), but with the introduction of mass retrofit schemes, demand has been more prevalent across all housing sectors. In the social housing sector, the market is building on the requirements of the Decent Homes programme; shifting the emphasis from kitchen, bathroom and windows to include energy efficiency. Current installer capacity for whole house energy retrofit is understood to be approximately 100,000 homes per annum.

2-Single Measure Retrofit: This involves the installation of a single energy efficiency measure for a property or the phased installation of measures over an extended period in what is essentially a 'piece-meal' approach. The selection and sequencing of measures using this approach can be divided into two sub-types:

2.1-Technical Led Approach: The building fabric is first addressed as single measures then the systems consequently changed at a later phase and sized according to the new fabric efficiency performance.

2.2-Funding Led Approach: Single measures (either fabric or systems) are determined and installed in a sequence based on the funding available at the time.

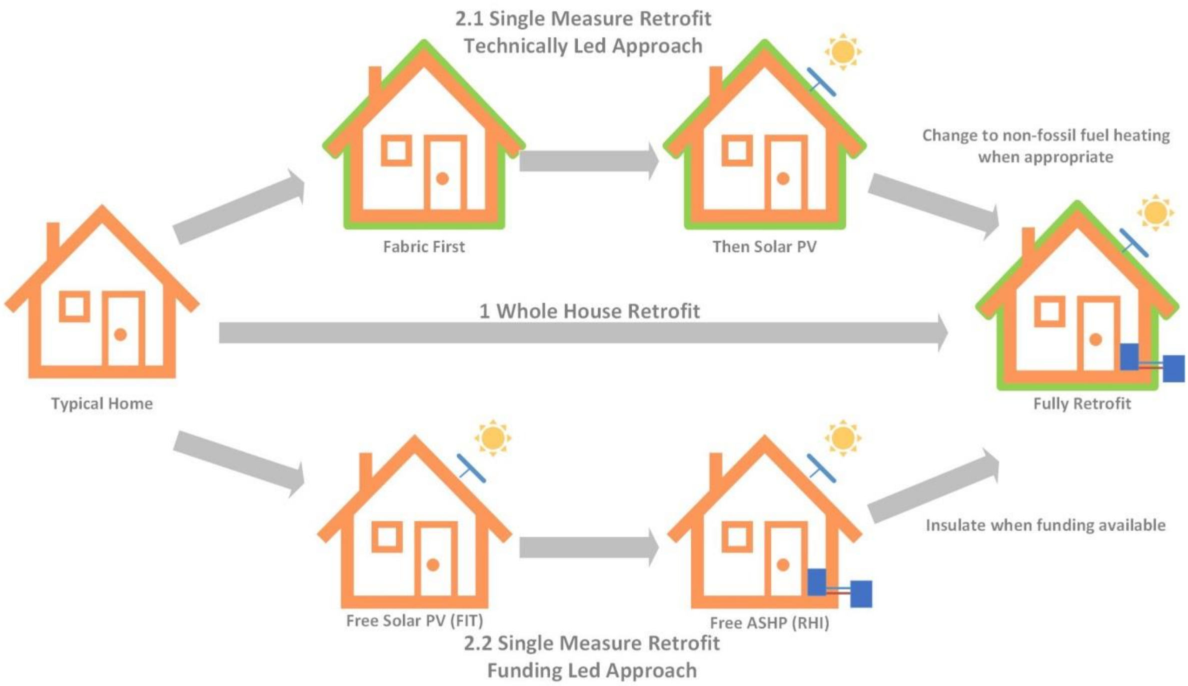


Figure 6 Delivery models: House scale approaches. Source: Banks, 2012

The second set of strategies for the delivery and deployment of EWI measures fall under the mass deployment approach, which describes how retrofit is delivered at scale to a number of properties (**Figure 7Error! Reference source not found.**). In regards to mass deployment, as no single delivery model can serve all of the individual types of households and communities in the UK, the following delivery strategies can be identified, in increasing scale of implementation:

1-Pepper-pot: This involves the installation in a number of selected properties within an area, whereby these properties may not be located near each other. This approach is often found in cases where retrofit is taken up by early adopters, where their properties may act as demonstrators to encourage uptake in an area.

2-Street-by-street: This also only includes a subset of properties within an area, however in this case a number of properties on a single street may undergo installation simultaneously allowing for more efficient supply practices as well as the opportunity for achieving economies of scale.

3-Area-based: This involves the deployment to all properties in a defined area (neighbourhood, estate etc.). This solution provides the greatest opportunity for achieving economies of scale, an opportunity for decreased project duration, but may involve increased disruption in the area.

At the area level, the street-by-street approach helps avoid problems relating to party walls, and technical details at the junctions between properties as well as the opportunity to unify building elevations to simplify planning processes and support improved streetscapes. Furthermore, it should be noted that for both the street-by-street and whole area retrofit approaches there is a significant opportunity to undertake retrofit programmes that are both sustainable and have the greatest potential to achieve cost-efficiency. This includes the ability to support the development of a sustainable supply chain that eliminates waste and minimises cost. In addition, significant cost savings can be achieved through economies of scale such as bulk buying, material depot efficiencies and spreading installer overheads such as site facility and scaffolding costs over many properties and installation teams (ETI, 2012).

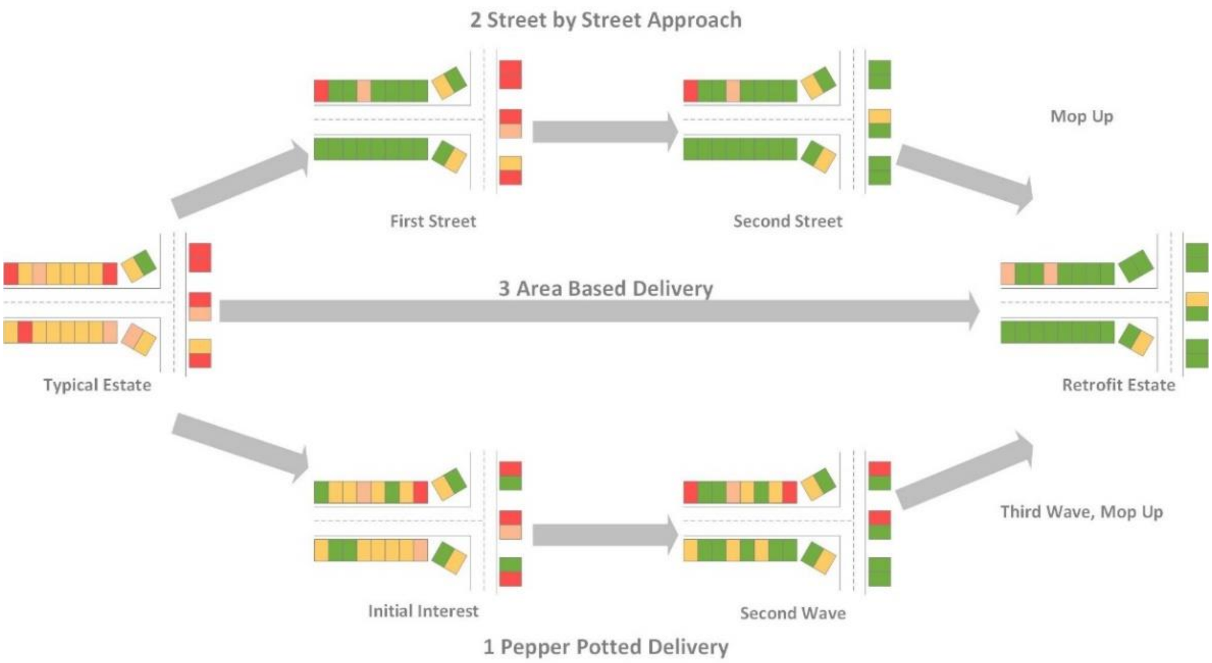


Figure 7 Delivery models: Area scale approaches. Source: Banks, 2012

2.2.2 Supply Chain and Deployment Best-Practice

Many factors hinder the effectiveness of the construction supply chain and they are often interconnected. Some key aspects pertaining to supply chain and deployment good practice include:

Targeting and supporting integrated large- scale delivery: The 'whole-house' and 'area-based'/ street-by-street approaches provide clear advantages to measure-by-measure / piece meal approach and pepper pot delivery. These approaches allow for economies of scale to be achieved and can reduce both the labour content together with eliminating waste within the supply chain to minimise cost. In addition, large-scale delivery ideally involves a detailed and integrated planning period in which EWI installation can be properly planned in terms of sequencing in the context of the project as a whole. The resulting integrated installation approach can provide an opportunity for the development of a set of packages linked to an established supply chain.

Integrated contracting: External sub-contracting practices and long sub-contracting chains tend to be less effective than a more contained and closely integrated team, and should therefore be avoided or minimised. While the use of a single sub-contractor appears to offer significant advantages, this option might not always be available or feasible in larger scale projects. In this case, there may be an advantage in using a small team of skilled people drawn from clusters of businesses who can develop trust and shared experience of retrofit over a number of projects (Raslan et al., 2012a). This approach, often referred to as the 'poly competent model,' can support local businesses by allowing them to participate in smaller jobs that fit their scale. Also, as shown in the case of the BIG Energy Upgrade Programme (Project 7), small businesses tend to feel disadvantaged in bidding for large-scale nationally funded projects. Integrating large and small local businesses can motivate local authorities and communities to engage with refurbishment projects.

Establishing supply chain collaborations and communication: With a diverse set of actors, multiple organisations are directly involved with the coordination and delivery of the same product. However, the poor management of multiple relationships across the construction supply chain is a main factor impacting on the overall quality of the process. Even if the process seems to work properly, this requires a high level of collaboration and communication, as well as the apportionment and management of risks. To address this, organisations involved should be guided towards establishing specific supply chain collaborations and maintaining clear lines of communication between them to avoid misinformation and duplication of work. Whole area regeneration case studies (Sefton and Bootle -Project 9, and a regeneration in Liverpool – Project 10) have shown that when in the absence of a social housing provider to deal with tenants and suppliers, issues such as delivery of materials, mortar splashes on walls, noise from construction works, and other disruptions resulted in some complaints by residents.

Adopting innovative supply chain solutions: The application of lean thinking[3] in the supply chain planning for process and flow of materials has been widely supported in particular for large-scale energy efficiency projects. This includes the implementation of strategies such as the use of (off-site) pre-prepared materials, a single site delivery route to minimise distribution costs and reduce delays and waste in all its forms (ETI, 2012). Previous work has suggested that projects in the social sector that have applied the principles at a smaller scale have reported considerable success in terms of reducing waste and time taken to undertake works. The work highlighted that lean thinking is more successful in projects which follow a logical pattern and informed process, where housing can be grouped to enable economies of scale and provide logistical advantages (Kempton, 2006). Lean

---

3 Lean thinking is an approach of production management to construction in which a clear set of objectives for the delivery process, aimed at maximising performance for the customer at the project level, concurrent design, construction, and the application of project control throughout the life cycle of the project from design to delivery (Aziz and Hafez, 2013).

thinking models for mass deployment are currently still in development in the UK through the ETI developed approach (ETI,2012) with some principles applied through the Energiesprong[4] approach currently being tested in areas around the country (Energiesprong, 2015).

Maintaining supply chains: The sector is dominated by single skill trades that are in short supply compared with demand, which directly impacts both efficiency of work practices and productivity of staff (Monetti, 2016). Workforce education and development is needed to maintain the 'human talent' supply chain for large-scale retrofit projects; professional certification schemes, national standards for contractors, and the provision of business development support for contractors, have been shown to be effective (Gooding and Gul, 2017). Successful projects, such as the LBH retrofit scheme (Project 2) integrated measures to maintain the skills supply chain with an overall community-focused approach to implementation by giving students from local college NVQ project work experience and securing permanent positions with installer partners for local residents.

4 Analysis work undertaken by UCL as part of the wider consortium for the GLA, has highlighted that the application of Energiesprong approach in the UK is still limited and requires further development in terms of its applicability to the stock and the economic viability of financial model.

2.3 Occupant and Community Focused Solutions

The key findings and recommendations from this section are:

- A range of social, institutional, personal and physical factors such as age, income level, environmental awareness and beliefs and social norms influence the knowledge of energy efficiency measures by households and consequently, its uptake or adoption.
- Occupant-inclusive planning and community integration are key aspects identified across all successful retrofit projects.
- A key factor highlighted as key in the promotion of the uptake of retrofit is the creation of targeted and robust Customer Value Propositions supported by the provision of financial indicators such as projected energy savings and potential payback periods of measures.

Retrofit is a major engineering challenge that requires the consideration of aspects beyond the physical upgrade of properties (Brown et al., 2014). Installing EWI is dependent on demand and acceptability from householders, therefore ensuring that EWI is appealing to householders through considered Customer Value Propositions [5] is important. Understanding the requirements of occupants (ranging from owner-occupiers to social housing and private rental tenants) and the community that surrounds them, is a key determinant in the success of retrofits. Important aspects to be considered can be broadly categorised into those that focus on the targeting of occupant segments during the pre-installation phase (influencing awareness and uptake) and those that consider the installation and post-installation phases (influencing engagement and experience).

2.3.1 Occupant Segments: Awareness, Acceptance and Uptake

A range of social, institutional, personal and physical factors influence the knowledge of energy efficiency measures by households and consequently, its uptake or adoption. This includes age, income level, environmental awareness and beliefs and social norms (Hamilton et al., 2014). Understanding why some households adopt and why their neighbours refuse the installation of EWI or retrofit work in general offers an opportunity to understand the set of complex decisions that impact uptake. A key factor affecting the uptake of retrofit is the creation of targeted and robust Customer Value Propositions (Mahapatra et al., 2013), supported by financial indicators such as potential energy savings and payback periods of measures.

Recent consumer-focused research was undertaken to inform the development of strategic approaches for the mass deployment of retrofit across the UK housing sector. This project considered the end-to-end value chain for dwellings while developing new solutions and delivery models that appeal to householders. In regards to EWI, the following points relating to consumer awareness, acceptance and uptake were identified (ETI, 2012):

- ***Awareness of EWI:*** While general knowledge of retrofit was typically poor across all occupant types/segments, most people were aware of measures such as loft insulation, cavity wall insulation and energy generation technologies like solar photovoltaic panels. However, almost all segments were found to be completely unaware of solid wall insulation.
- ***Acceptance of EWI:*** Cost was identified as being a primary focus of occupants across all segments (from upfront cost to potential savings achieved). As a high-cost measure, the acceptance of EWI is therefore a particular challenge with occupants more likely to require more information, as well as time, to inform their investment decision. Acceptance is also more likely if

5 This is a business or marketing statement/offering that is targeted at potential customers and describes why they should buy a product or use a service by highlighting its value (i.e. potential benefits) to them (Hall and Roelich, 2016).

an array of non-energy-related benefits such as environmental and health and comfort benefits are highlighted to showcase the desirability of EWI.

- ***Uptake of EWI:*** Beyond awareness and acceptance, uptake signifies the conversion point where knowledge and desirability of EWI translates into actual installations. Potential segments identified as ‘early adopters’ in the uptake of EWI, and more interested in retrofit generally, include older groups as well as consumers with moderate income levels. When combined with key trigger points, these segments were found to be more receptive to potential customer value propositions.

2.3.2. Occupant Engagement: Experience and Satisfaction

Information is vital for effective engagement, enabling occupants to make informed decisions about their energy efficiency and formulate reasonable expectations of both the process and its outcomes (SDC, 2006). This is particularly important in cases where occupants will be living in an active construction site for the duration of the works (Raslan et al., 2012b). From an implementation perspective, valuable design lessons can be learned by engaging with occupants. Here, feedback can help address any arising issues and thus ensure that the measures introduced are accepted by a wider range of occupants. To obtain this feedback, a variety of handover strategies such as occupant meetings, information sessions and walk-throughs can be used.

The interaction between the delivery team and occupants can have significant impacts on the success of the delivery programme (as demonstrated in Projects 6, 10 and 11). Inconsistent information provision can lead to dissatisfaction with the process resulting in a lack of cooperation, installation delays and additional financial costs. Future participants may also drop out due to the problems or inconvenience that occupants in the programme have endured. Dissatisfaction may also extend to the installed works which may result in its removal or replacement at an additional cost.

Research has highlighted the importance of factoring in occupant lifestyle, behaviour, commitment to the project and awareness of the environmental issues as well as the influence of personal positive experiences with trades and personal recommendations from friends and family in helping customers select services to carry out works (ETI, 2012).

2.3.3 Occupant and Community Best-Practice

Occupant inclusive planning: The planning and design of energy retrofitting around occupant everyday practices is a key aspect to successful projects. Planning processes that include a feedback loop and early dialogue between experts and householders have the potential to include this perspective. Therefore, rather than viewing retrofit as a purely technical matter, a process where expert views and home-owners’ perspective can interchange is desirable (Vlasova and Gram-Hanssen, 2014).

Community integration, regeneration and whole area-uplift: An evaluation of the impact of a community-led project motivating homeowners to undertake retrofit found that the majority of homeowners saved energy due to interventions combining technical and behavioural approaches, and highlighted the key role of community projects in developing a wider culture of energy efficiency (Gupta et al., 2014). Harnessing the power of these personal networks is therefore essential in rolling out retrofit on a wider scale. Nationally or regionally-funded regeneration schemes provide an opportunity for incorporating energy efficient mechanisms. For example, a large-scale EWI was undertaken in a deprived area of Stockton on Tees (Project 8), as part of a larger project involving demolition, construction and refurbishment. The project was mainly funded through a government scheme and as the majority of homes were not privately owned, energy saving was regarded as an important priority for many parties but was not the sole driver for carrying refurbishment works. It was in practice viewed as one element in a larger-scale regeneration plan, to uplift the whole area and make it more attractive.

Effective communication strategies: A strategy for liaising with occupants and neighbours should be established as early as possible. This can help avoid such issues as miscommunication and the subsequent mismanagement of expectations. The early engagement of neighbours is a key aspect in the implementation of future mass deployment strategies to ensure effective coordination and implementation of works. This allows for the planning of works to accommodate their requirements while helping to address their concerns throughout the period. Aspects that should be discussed include the acceptable level and type of disruption, and in the case of potential major disruption, options for decanting and storage facilities for possessions (Raslan et al., 2012b).

Provision of advice: Because of unanticipated potential effects of EWI (**section 2.5**) and various maintenance aspects (e.g. EWI susceptibility to damage from point loads[6]), it would be pertinent for EWI systems to come with a user guide and/or a requirement to give verbal advice to the householder. This should mitigate potential issues and allow occupants to get the best from the system (EAGA, 2013). This is demonstrated in Linlithgow Climate Challenge (Project 6), where a professional local advice centre was involved, answering homeowner questions, securing the best deal from installers and acting as a first point of verbal contact for householders.

Encouraging uptake: A number of aspects may influence an occupant's decision to take up EWI, and promoting these benefits while understanding the specific triggers associated with owner-occupiers and private and social tenants may enhance uptake for each group. For example, in the Irish Home Energy Saving scheme (Project 5) private owner-occupier interviewees named improved thermal comfort and the availability of government funds as the main incentive for undergoing retrofit. Lower energy bills or increased property value were not specifically cited as a main motivation. However, the high visibility of EWI and its impact on the appearance of a property could be a factor in marketing it as a 'home improvement' measure for owner-occupiers in particular. Branding it as such may enhance its appeal to occupants and better portray the nature and (relatively higher) cost of work involved (EAGA, 2013). Similar strategies focusing on highlighting lower energy bills and better living conditions may be used to promote uptake for the private and social rental sectors. The GMCA case study has shown that engaging multiple stakeholders while approaching potential clients (the council and contractors, in particular), proved to result in higher uptake, as the initiatives were perceived as being 'more reliable'.

[6] Point loads are concentrated loads applied along the span of wall. In domestic buildings these may include drilling holes to affix satellite dishes, washing lines and external shading devices.

2.4 Regulation and Funding

The key findings and recommendations from this section are:

- Mass deployment of EWI remains relatively limited despite a number of Government programmes and policies to improve energy efficiency in the built environment.
- External solid wall insulation is typically more expensive than internal solid wall insulation (£8,000 - £22,000) with payback periods of 12 to over 40 years and an installation life of 25-30 years.
- Cost varies considerably across dwelling types, tenure sectors and material type used, where delivery to social housing is considerably lower (~25%-50%) than the private sector. Economies of scale across sectors (100+ installations) have been estimated to bring costs down by over 25%.
- The impact of EWI on property price is uncertain, however estimates have found that energy efficiency increase real estate price by 9%.
- Cost efficiency describes the savings that can be achieved through effectively designed and implemented EWI installations that meet or exceed minimum standards and deliver real savings in practice for occupants. These can be considered at a number of stages where key opportunities to improve performance at low cost can be achieved.
- Work with experienced team with the necessary time, experience and skills is initially more costly but more cost effective over project duration.

2.4.1 Funding Pathways

The UK Government has implemented several policies to encourage the improvement of energy efficiency in homes (Table 4**Error! Reference source not found.**). While grants such as the Warm Front (Hong et al., 2009; Power, 2008) focused on the roll-out of mass scale retrofit for the low income and social housing, others aimed to achieve this via the involvement of energy suppliers (DECC, 2012; Duffey, 2013) and covered a wider range of properties through a market-based framework (DECC, 2012; Rydin and Turcu, 2013). At the end of 2015, ECO and the Green Deal had improved the energy-efficiency of more than 1.4 million homes where the vast majority (96%) were improved through ECO. The schemes provided 1.7 million measures, of which, solid wall insulation accounted for less than 10%, below its target of 100,000 per year from 2015 onwards (**Figure 8Error! Reference source not found.**). Of the programmes listed below, the only remaining scheme is the ECO transition (ECOt2) which extends the current solid wall minimum requirement (at a reduced level), with suppliers required to insulate the equivalent of around 32,000 additional solid walled homes (21,000 per year) (BEIS, 2017b).

Table 3: Key initiatives for home energy efficiency and retrofit in the UK

Sources: Abraham, 2013; DECC, 2012; Duffey, 2013; Ofgem and EST, 2003; Power, 2008; Rydin and Turcu, 2013

Program	Period	Description	Covered Measures
Energy Efficiency Standards of Performance (EESoP)	1994-2002	First programme of its kind & scale, setting energy saving targets on domestic suppliers.	Insulation, lighting, heating & appliances
Energy Efficiency Commitment (EEC)	2002-2008	An extension & expansion of the EESoP.	Insulation, lighting, heating & appliances
Warm Front (Prev Home Energy Efficiency Scheme)	2000-2013	Energy efficiency grant scheme targeting private low-income households in England.	Insulation, heating system & draught proofing.
Decent Homes Programme	From 2000	Government investment programme to bring social housing up to a decent standard by 2010.	Basic repair, weatherproofing, kitchens & bathrooms.
Carbon Emissions Reduction Target (CERT)	2008-2012	Energy suppliers' requirement to reduce energy demand from domestic consumers (Priority/Super Priority groups).	Insulation, replacement of appliances and installation of micro-generation & CHP.
Community Energy Saving Programme	2009-2012	Part of the Home Energy Saving Programme. Required gas & electricity	Solid wall insulation & boiler replacement.

(CESP)		suppliers/generators to consumers in low income areas.	
The Green Deal	2013-2015	Financing mechanism & framework of advice & encouraging take-up of retrofits loans	All eligible measures covered under the 'Golden Rule'
Energy Company Obligation Schemes (ECO/ECO2/ECOt2)	From early 2013 -	Carbon Saving, Carbon Saving Communities & Affordable Warmth obligations. Focuses on vulnerable households & HTT properties	Solid and cavity wall insulation, boiler replacement & renewable technologies.

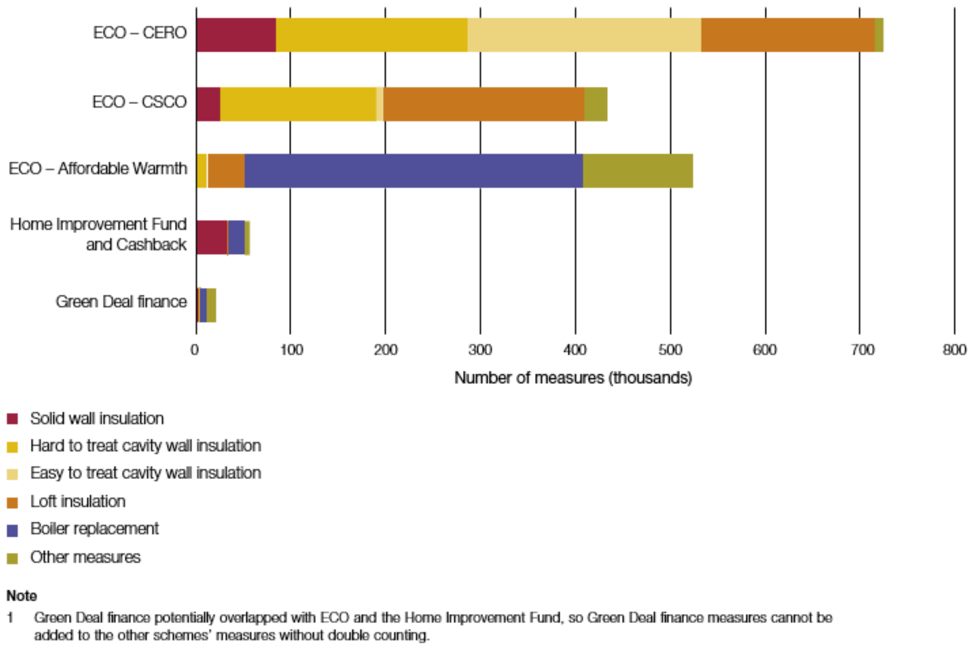


Figure 8 Total measures installed under ECO and Green Deal by 31 December 2015, by scheme. Source: NAO, 2016

2.4.2. Cost Estimates

Estimating costs for EWI is much more complex than for other energy efficiency measures such as loft insulation, as the costs are determined by a number of factors (Changeworks, 2012). There are a wide variety of estimates of standard costs for EWI, where the EST has estimated the total cost of installing external solid wall insulation for a single house to be between £8,000 to £22,000 (**Table 4**)(EST, 2016).

Table 4 Solid Wall insulation: Costs and savings. Source: EST, 2016

		Detached	Semi Detached/ End Terrace	Mid Terrace	Bungalow	Flat
Fuel bill savings (£/year)	ESW	£455	£260	£175	£180	£145
	NI	£390	£225	£150	£155	£125
Carbon dioxide savings (kgCO_2/year)	ESW	1,900 kg	1,100 kg	740 kg	750 kg	610 kg
	NI	2,300 kg	1,300 kg	900 kg	920 kg	720 kg
Typical installation costs*	External wall insulation: £8,000 to £22,000					

ESW: England, Scotland and Wales, NI: Northern Ireland
*Estimates based on insulating a gas-heated home, March 2016 fuel prices. Above estimates are based on a typical install. Costs may vary significantly depending on level of work required.

Property type variation
Indicative figures, taken from the DECC Green Deal Consultation, for the costs of installations in different property types which vary in size are considerably lower (**Table 5**), although it should be noted that these are in some instances based on multiple installations (Changeworks, 2012). A number of case studies noted that bespoke EWI system drawing packs had to be developed for

different archetypes and styles, to ensure the installation contractors knew exactly what to do (Projects 1 & 4). These will, most often, incur further costs.

Table 5 Installation costs for different property types. Source: Changeworks, 2012

Property Type	Installation cost of EWI
Detached	£12,494
Semi Detached/End Terrace	£10,009
Mid Terrace (multiple installations)	£5,908
Bungalow	N/A
Flat (multiple installations)	£5,899

Sector variation

Information collated from a comparison of the specific costs of EWI delivered through a number of projects that were reviewed in a Consumer Focus report differentiated between delivery to the private and social sectors (ACE, 2011). Private sector costs were in general higher than social sector estimates. The average cost of SWI delivered in the Sutton PAYS pilots was just under £16,300 (pilot projects were larger than the UK average). Similar average costs of £15,750 for EWI (range £12,500 to £19,000) were found in the Warm Streets scheme. In the social sector, PAYS pilot partner Gentoo found costs for EWI to be around £6,500 per property (**Table 6**).

Table 6 Published average costs of EWI for private and social sector housing. Source: Adapted from AECB, 2011

Source/Sector		Social Housing	Private Housing
Purple market research		£8,400 (100 properties)	£10,600-£14,600
Energy Bill Impact Assessment	Installed cost	£4,800 (3 bed semi) £3,160 (flat)	£7,600
	Total costs*	£7,164 (3 bed semi) £4,730 (flat)	£9,300 (with major refurbishment) £12,766 (single installation)
CERT Ext Impact Assessment	Installed costs	PG £5,906 Non-PG £6,544	PG £11,812 Non-PG £13,089
	Incl. admin	PG £6,188 Non-PG £6,761	PG £12,117 Non-PG £13,321
CESP Impact Assessment		£3,600 (flat) £6,300 (3 bed - semi)	

*Total costs include installed costs, admin, making good, household time costs, disruption and loss of floor space
PG= Programme grant

Economies of scale

In terms of economies of scale, in some cases, an increased number of properties might reduce some aspects of installation costs. This is highlighted by available indicative costs for EWI from 2008/9 (**Table 7**) that include material, installation and additional costs (excluding VAT) and is illustrated in the case of Projects 2 and 10 for example (Project 2 is especially interesting as it showed the engagement of a local advice centre to find local installers who could secure the best installation deal). However, a recent report suggests that many of the high costs such as logistics, planning permission, scaffolding, unexpected works and making good are fixed which means that cost reduction though economies of scale, although significant, may not be reduced as much as originally predicted by the initial DECC Green Deal analysis (Changeworks, 2012).

Table 7 EWI costs: Impact of economies of scale. Source: Martlet, 2010

	Total Cost	Average Cost
EWI – single property	£10,600 – 14,600	£12,600 (midpoint)
EWI – multiple properties under 100	£7,600 – 13,500	£10,000
EWI – multiple properties 100+	£6,300 – 10,000	£8,500

Payback periods

The estimated payback period of EWI is highly variable, ranging between a minimum of 12 years with a standard (non-warranty) installation life of 25-30 years (TTHW, 2012) to over 40 years in some cases (NIHE, 2014). According to the figures published by Shorrock et al. (2005) the payback period for the cost of solid wall insulation of a typical 3-bedroom semi-detached house is 22.4 years[7]. Across various house types, the typical payback time is slightly lower at an estimated 15-20 years (Purple Market Research, 2008).[8]

Cost determinants

Fixed costs refer to the overheads that are unlikely to change regardless of the change in factors such property type, scale…etc. These are generated in a number of ways and can contribute up to 50% of the total costs involved. These generally include programme costs (particularly in the case of government programmes such as CESP), design specification, logistics and programme set up (e.g. financing, assessment and monitoring), fixed installation costs such as scaffolding and regulation/planning (AECB, 2011 & EU directorate 2016).

Further to this, one of the main cost determinants of EWI is the material type used (**Table 8**). While different materials vary in both cost (often by around 20%) and performance, they on average account for 30-40% of the total install costs (Changeworks, 2012). An example of the complex costing methodology based on both a performance and pricing matrix is provided in Appendix A.3 of this document. The method, developed by ProcurePlus (ProcurePlus, 2017), for procuring insulation systems represents the complexity faced by both public sector and private sector clients and consumers looking to procure insulation systems. This has been attributed to the lack of uniform standards and metrics relating to the difference performance characteristics of insulation materials (such as decrement delay, moisture handling / movement, dimensional stability etc.). A key point raised by the Bonfield Review addresses this issue by highlighting the need for simple and transparent differentiation between products to enable customer choice (Bonfield, 2017).

Beyond material cost and performance, additional aspects will impact the calculated payback period and should therefore be also taken into account. For example, mineral wool is generally lower cost (i.e. cheaper to buy as an insulating material) than rigid board, however the following additional aspects should be considered:

- Installation 'sundry' costs: While mineral wool is inexpensive compared to rigid board it increases foundation sizes and incurs associated 'sundry' costs such as cavity trays, closers, lintels and wall ties.
- Labour costs: Rigid insulation generally takes longer to cut and fit than other insulation types; and is therefore associated with an increased installation labour costs.

Table 8 Typical comparative costs/performance of common UK insulation systems as applied to an end terrace house. Source: Adapted from Telow et al., 2015

Insulation type	EPS (superior)	Mineral Fibre (superior)	Polyurethane	Phenolic	VIPs (superior)
λ-value (W/m.K)	0.035	0.035	0.028	0.021	0.007
Thickness (mm)*	100	100	80	60	20

[7] Payback calculations based on the following assumptions: no grants were available and 30% of the energy saving is taken as 'take back' effect as result of home owners increased thermal comfort post retrofit

[8] As per Building Regulations requirements (AD Part L1B), if a solid wall is upgraded by the installation of insulation it must meet the minimum energy efficiency values (an area-weighted U-value of 0.3W/m2K for the whole element). If this upgrade is not technically or functionally feasible (i.e. would result in a simple payback of more than 15 years), a higher, less stringent U-value may apply. This would need to be agreed with Building Control in advance of works being carried out.

Typical cost range (£/m2)	65 -70	65 -70	75 -80	80 - 85	25 - 130
Cost (£)	7350	7350	8400	8925	13650
Payback** (years)	16.6	16.6	18.75	20	30

* Required thickness values to reduce external façade U-Values to retrofit regulation requirement
**based upon a 75% saving on annual gas bill of £600 [UK national average. This is assuming the maximum installation cost per square meter shown is used in the calculation for the retrofit install

Cost responsibility

In terms of overall cost breakdown and responsibility, as with building retrofit in general, EWI costs can be split between the various stakeholders involved. These include property owners, public authorities and tenants if buildings are rented or leased (EU Directorate, 2016). These costs and burdens, as well as the stakeholders responsible for meeting them, are summarised in **Table 9.**

Table 9 Cost breakdown and responsibilities for different stakeholders. Source: Adapted from EU Directorate 2016

Property Owners & Landlords	Government/ Local Authorities	Tenants
•**Assessment costs:** Surveys for installation assessments & finance arrangements. •**Installation costs:** Implementation of measures •**Financing costs:** Application/ (commercial) loan costs •**Hidden costs**: Contracting, rehoming, storage, clean-up costs…etc. •**Costs of understanding Regulations:** Planning assessments & applications	•**Set up costs:** Staff training, Information campaigns…etc. •**Implementing, administrating, monitoring costs:** Set-up of stock databases to support policies etc. •**Other costs:** e.g. advising on regulations, assessing compliance, dealing with complaints related to the supporting policies… etc.	•**Potential rent increases** •**Hidden costs:** Rehoming, storage, clean-up costs etc.

2.4.3 Cost Efficiency

Cost efficiency refers to savings that can be achieved through effectively designed and implemented EWI installations that meet or exceed minimum standards and deliver real savings in practice. Various metrics are used to assess cost effectiveness of energy efficiency measures, such as:

- **Value for money:** To assess the value for money for energy efficiency schemes such as ECO, the National Audit Office uses a standard approach which looks at the cost per tonne of CO_2 saved. This is based on the total capital costs for the grant funding element of schemes, where revenue costs are not included.
- **Lifetime savings:** These are the savings that will be achieved over the assumed lifetime of installed measures. Calculations for this metric are based on the assumed lifetime of each measure published by Ofgem. The in-use factor for SWI depends on the age of the building and construction type. Where the installation is accompanied by an appropriate guarantee, the standard lifetime of the measure considered for the calculation can be extended from the standard 23-30 years to 36 years (Ofgem, 2013).

From a household investment perspective, it should be noted that due to the small number of installations that have been implemented to date, projected energy bill savings from solid wall insulation are largely based on estimates. Furthermore, a literature review by BRE highlights the considerable uncertainties around the reliability of these estimates (BRE, 2014a). Current analysis by the energy Saving Trust, Purple Market Research, DECC/BEIS undertaken by the National Audit Office shows that on average, in most homes, EWI tends to save less money on lifetime bills than the current cost of installation (NAO, 2016).

The effect of solid wall insulation on property value is also uncertain. While some value can be assigned to the lower levels of energy consumption, lower values may result from any reduction in aesthetic appeal (BRE, 2014a). Typically, the effect of energy efficiency improvements on real estate prices has been analysed through a hedonic pricing method where the price of a marketed good is related to its characteristics, or the services it provides. Based on this, an increase of 9% in selling price was estimated for homes in Switzerland with a “Minergie” energy efficiency certification (Ürge-Vorsatz et al., 2010).

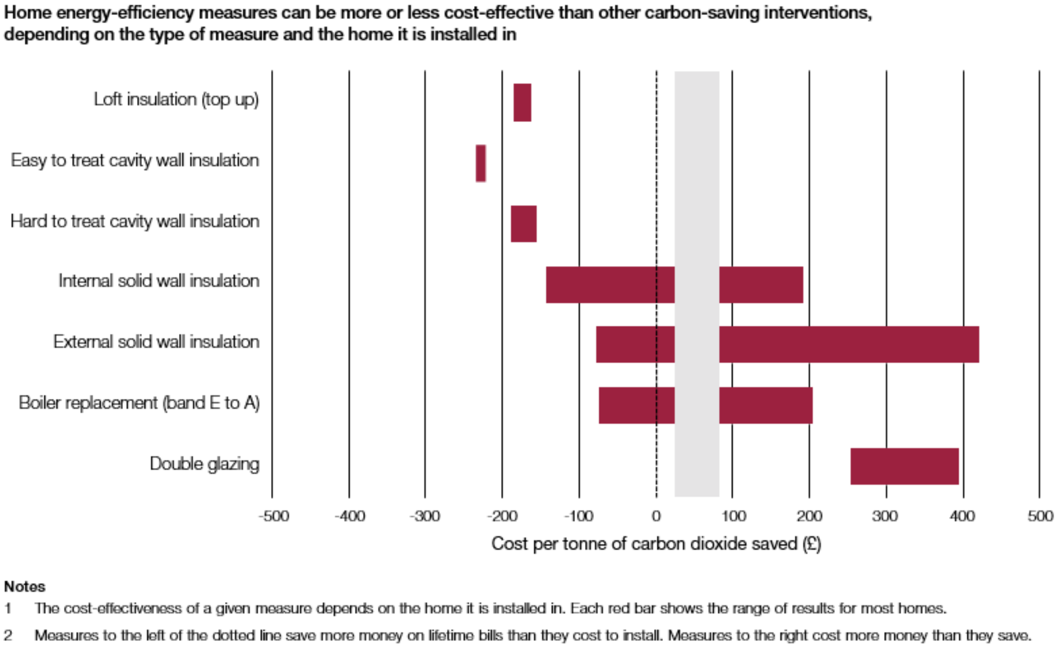


Figure 9 Cost-effectiveness of saving carbon dioxide with energy-efficiency measures. Source: NAO, 2016

From a wider investment perspective, Rosenow et al. (2014) undertook a modelling based exercise to assess the impact of a scheme to support the uptake of solid wall insulation measures across the UK domestic housing stock on the Exchequer. A set of investment options (**Table 10**) was analysed using peer-reviewed and other validated assumptions where no peer-reviewed evidence existed. Two scenarios were considered, where a low revenue scenario reflected very conservative parameters around cost and benefits and the high revenue scenario included parameters associated with larger uncertainties.

Table 10 Solid wall uptake analysis: Investment options modelled. Source: Rosenow et al 2014

Option	Funding source	
	Private finance (%)	Subsidy (%)
Option 1—private householder scheme	33.3	66.6
Option 2—social housing scheme	50	50
Option 3—loan scheme	80	20

The analysis suggested that the significant amount of the cost of a scheme funding solid wall insulation would be offset by increased revenues and savings. Where a loan scheme, due to the high leverage, achieved budget neutrality and generated additional revenue for the Exchequer (**Figure 10**). It should be noted while these financial benefits are significant, they are dispersed across multiple revenue streams and parts of the supply chain. Therefore, policy makers should ideally assess the fiscal impacts of schemes beyond the programme cost in order to get a better understanding of their impact on the public budget.

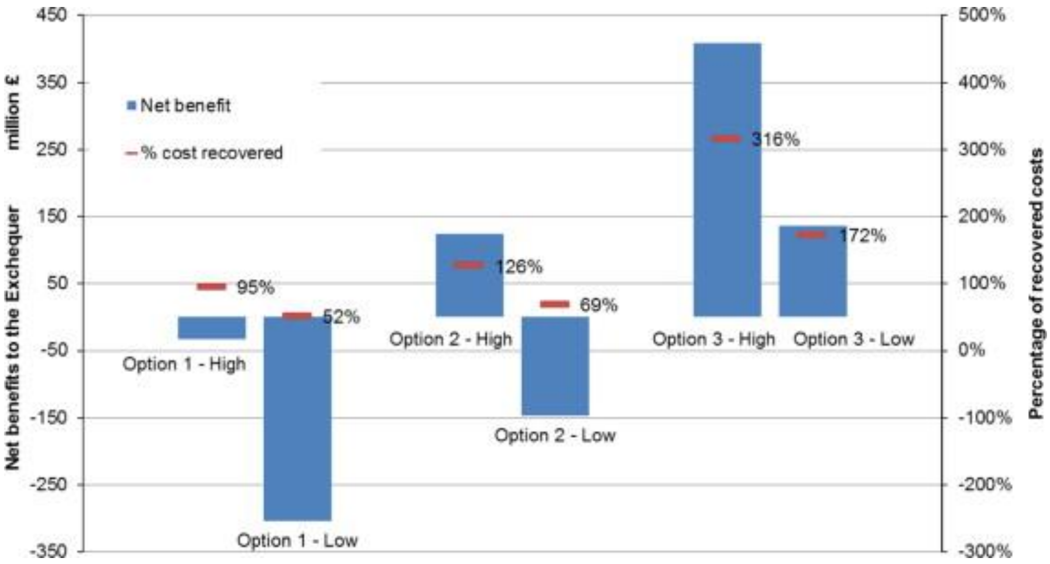


Figure 10 Exchequer analysis summary of a solid wall insulation scheme. Source: Rosenow et al. 2014

Following the Bonfield Review (Bonfield, 2017) and in light of the changes to available funding pathways, work currently being led by such organisations as Insulation-Consumer Action Network is exploring how financiers and insurers may be able to provide better market solutions for energy efficiency with the aim to make cost effective finance more accessible to a wider proportion of the industry and their customers (I-CAN, 2017).

2.4.4 Cost Reduction

Cost reduction strategies can be considered at a number of stages where key opportunities to improve performance at low cost can be achieved, while highlighting some of the risks of poorly conceived or executed approaches. The Zero Carbon Hub Cost Effectiveness Guide (ZCH, 2016) provides advice as to the considerations affecting costs. The key aspects that relate to the deployment of EWI are summarised in **Table 11**. In relation to EWI, the main aspect reported by the stakeholders interviewed as part of the Consumer Focus study (AECB, 2011) suggested that, to date, the main opportunity was related to the cost of materials supplied in one large-volume contract. Some potential in the development of materials and installation techniques to reduce costs was identified (e.g. simplification of fixings and the pre-treatment of insulation materials to reduce on-site installation time and labour costs).

Table 11 Key considerations for cost effectiveness. Source: ZCH, 2016

Stage	
Planning	• Experienced Teams: With the necessary time, experience & skills. These are initially more expensive but more cost-effective over project duration. • Engagement with planning: Early engagement to establish requirements or constraints rather than incorporating them at a later date.
Design & Detailing	• Expert advice: The advice of an energy specialist can help address issues such as suitability of materials, continuity of insulation…etc. • Practical design decisions: Key design characteristics e.g. to deliver thermal bridging or air tightness targets should be prioritised & delivered through approaches that are suitable & buildable. The incorporation of new technologies or construction details should be balanced. • Production of a construction programme: Incorporated early & updated to control overheads. • Material selection: Select appropriate materials & investigate the best suppliers for key technologies. This will increase efficiency on site & should reduce cost.
Specificatio n	• A detailed specification: Should be produced & communicated clearly to reduce the risk of costly errors in procurement or construction.
Installation	• Facilitation of installation: Difficult to access areas take longer to complete or not finished

	correctly. May result in additional construction costs or in complaints & expensive return visits after handover. • Site manager / clerk-of-works: Who is aware of quality control requirements to ensure that products are correctly installed. Significantly less expensive than making changes following failed inspection. • Sub-contractors with necessary skills/identify any training requirements: To increase the speed of installation, improve the quality of the build & reduce cost in the long term. • Communication: Finalise the programme & sequencing & communicate with the project team. • Quality management checklist: This should cover e.g. thermal bridging, airtightness continuity of insulation, correct specification, installation & commissioning to encourage high quality construction.
Handover	• Provision of guidance: Simple & clear guidance & appropriate occupant training to ensure they know how to use their home will improve understanding & reduce the need for return visits.

2.5 Unintended Consequences: Risks, Impacts and Causes

The key findings and recommendations from this section are:

- Current retrofit measures in the UK may not be as effective as anticipated. This is generally the result of such aspects as the lack of monitoring, poor quality installation and the increased use of heating post refurbishment.
- In regards to EWI, the main issues associated with unintended consequences include the performance gap, overheating, thermal bridging and moisture and mould problems in retrofitted homes.
- The main underlying causes that have been identified as contributors to issues relating to EWI are poor on-site workmanship, a lack of accuracy of information/quality of communication, incorrect/uncertainty in assumptions regarding existing constructions and the impact of the rebound effect in occupants.

Recent studies have highlighted that in the UK retrofit measures have failed to deliver the anticipated savings they were installed to achieve. This has generally been attributed to the lack of monitoring undertaken to properly quantify savings, the poor on-site installation of measures and the increased use of heating post refurbishment in what is referred to as 'comfort-taking' or the 'take-back factor' (Dowson et al, 2012). Extensive academic literature outlines the risks of unintended consequences in solid wall insulation (Forman, 2015). A BRE report analysis of previous projects (BRE, 2014a) indicates that these can be categorised into five main areas:

1. Systemic — Built into the process of design, certification and testing of systems
2. Assessment — Built into the process by surveys that do not capture or appreciate important factors affecting the performance and durability of systems
3. Workmanship — Lack of controls on-site and deficiency in understanding of installation requirements
4. Design — Weaknesses in design; particularly around geometrical obstructions
5. Process — Issues introduced at all stages of the installation process, predominantly related to quality assurance procedures and practices

While issues associated with installing EWI are seemingly less significant than IWI (BRE, 2015), these can be summarised as:

***Performance Gap*:** A potential barrier to the widespread acceptance of retrofit measures is the performance gap that is often observed between the predicted and the actual post-retrofit energy performance of a building (Loucari et al., 2016). A range of studies have reported failure to achieve the anticipated post-retrofit performance. In a report analysing the results of the post retrofit performance of 37 of solid wall properties across the UK that aimed at an 80% reduction in energy use, only three properties achieved the anticipated savings (TSB, 2013).

Overheating: It is recognised that overheating can be a problem in all homes which have received solid wall insulation. This is a particular problem for properties that have been treated with internal wall insulation as a result of decoupling of thermal mass from the building. However recent evidence from a case study where EWI was applied to a bungalow as part of a package of improvement measures also suggests that EWI may also contribute to degree of summer overheating (BRE, 2016).

Thermal bridging: Where a complete covering of insulation is not achieved, cold un-insulated areas, referred to as thermal bridges, concentrate condensation (Hopper et al., 2012). While compared to IWI, EWI reduces the risks posed by unavoidable thermal bridging, it is also susceptible to it since achieving a complete covering of EWI at particular critical junctions to prevent all thermal bridging during installation can be challenging (**Figure 11**). These junctions include: window and door openings; wall to roof junctions; window sills; and any projections, such as porches and conservatories (Hopper, 2012). Thermal bridging can lead to increased heat loss and thus a reduction in the overall thermal performance of the EWI, along with internal surface condensation due to localised lower surface temperatures. The risk increases with a greater level of insulation.

Moisture and Mould: The most serious effect of internal surface condensation is the risk of moisture, damp and mould growth. These can lead to severe health-related consequences for occupants such as respiratory diseases, asthma, fungal infections, nausea and diarrhoea; and depression and anxiety (Hopper, 2012). The vulnerability of solid walls to moisture is dependent on a number of factors such as exposure to driving rain, ability of wall to absorb moisture, wall thickness, internal moisture from clothes drying and the type of insulation used.

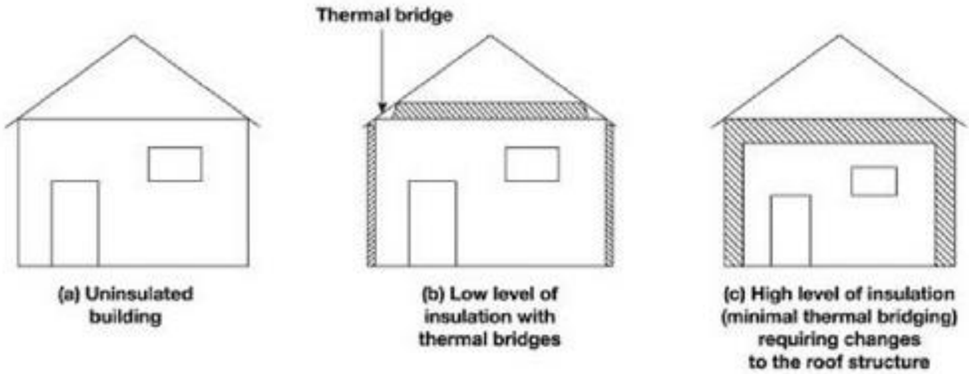


Figure 11 The addition of EWI to an uninsulated building can result in the need to change roof pitch and eves or for the roof to lifted to be avoid thermal bridging. Source: Galvin 2011

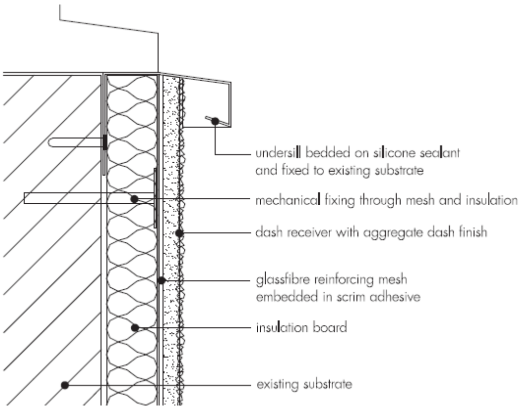
The main underlying causes that have been identified as contributors to issues relating to EWI can be listed as:

On-site workmanship: The majority of the unintended consequences resulting from EWI are linked to poor quality workmanship (BRE, 2015). Unintended consequences commonly result from poor butting of insulation, the introduction of additional materials (sealants), inconsistent fixing, and insufficient care around openings and storage of materials (BRE, 2014b). Robust and consistent checks and inspections can help to minimise unintended consequences (Error! Reference source not found.).

Accuracy of information/quality of communication: Mistakes in the initial assessment of the buildings for their suitability for insulation have also been identified as a major contributor to EWI failure. This is particularly the case when adequate preliminary surveys and technical details are not undertaken (BRE, 2015).

Uncertainty in assumptions: A key aspect associated with unintended consequences of EWI is the uncertainty in determining the pre-retrofit performance of solid walls. A study commissioned by DECC and undertaken by UCL found that the mean U-value of English solid-walled properties is 1.3 $Wm^{-2}K^{-1}$ which is significantly lower than the CIBSE Guide A value of 2.1 $Wm^{-2}K^{-1}$(Li et al., 2015).Further findings in a follow-on study also undertaken at UCL study indicated that the uncertainties in solid wall U-values could result in a substantial performance gap and, more importantly, to significant under-performance of retrofit measures. More specifically, for solid wall dwellings with U-values of as low as 0.64 Wm $^{-2}$K^{-1}, savings could be reduced by up to 65% (Loucari et al., 2016).

The rebound effect and behaviour change: 'Rebound effects' or 'take back factor' are widely used umbrella terms for a variety of economic responses to improved energy efficiency and energy-saving behavioural change. The net result of these is to typically increase energy consumption and greenhouse gas (GHG) emissions relative to the baseline in which these responses do not occur as well as its implications for evaluating health impacts (Chitnis et al., 2014). In under-heated, hard-to-treat homes, the main health benefit of EWI will be taken in the form of increased comfort, with people living at higher temperatures, which results in lower levels of admission to hospital due to health issues and fewer days off school and work. Nottingham City Homes' recent study, Warm Homes for Health, has also highlighted these savings to the NHS. Where, occupants in solid wall homes had reduced numbers of visits to the doctors after their homes had been insulated and that they experienced an improvement in their mental health and wellbeing (NCH, 2016a). This was further recognised in a recent consultation by the National Institute for Health and Care Excellence (NICE) on Excess Winter Deaths and Illnesses (NICE, 2015). Analysis shows that inefficient and poor quality housing costs the government around £760 million each year through impacts on the NHS. Investment in energy efficiency measures such as EWI installations can go some way to reducing these costs (Platt and Rosenow, 2014).



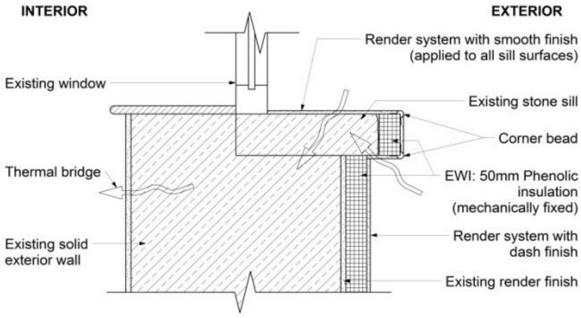


Figure 12 The execution of retrofitted external wall insulation for pre-1919 dwellings in Swansea (UK), detail in BBA certificate (left) vs on sie execution (right) Source: Hopper et al., 2012

In addressing the impact of unintended consequences of energy efficiency measures often resulting from the inconsistent standard of work provided by contractors, the Bonfield Review (Bonfield, 2016) highlighted a set of recommendations including the introduction of a retrofit quality mark and a simplified and effective redress process, where consumers have a single point of consumer contact. I-CAN is undertaking analysis with financiers and insurers to explore how liabilities are covered with the aim of improving customer experience in terms of assuring consumers that they are dealing with approved installers and manufacturers and that products perform as customers expect, backed up by insurance giving customers peace of mind (I-CAN, 2017).

3. Project Reviews: Demonstrating Best-Practice

3.1 Introduction

Case studies provide a pragmatic method of investigation when ‘how’ and ‘why’ questions are being posed and the focus is on a real life phenomenon. The analysis of case studies within the remit of this project offers the opportunity to identify lessons learned, enabling a set of Best-Practices to be defined. These are proven, real-world technologies and processes that should be carried forward in future building practice (Torcellini et al., 2006). To achieve this, stakeholders involved in the roll-out of large-scale retrofit schemes in the UK were engaged to identify ‘exemplar’ projects. Following this, five projects (summarised in **Table 12**) were selected for analysis through the undertaking of hindsight review meetings. The methodology for case selection and the procedures involved in undertaking hindsight review meetings are detailed in **Appendix A-4** of this report.

During these meetings, which typically lasted between 90-120 minutes, the stakeholders (i.e. project consortia partners) involved in delivery were invited to discuss the project using a pre-prepared agenda and project information as a guide for discussion (**Appendix A-5**). To incorporate wider perspectives, where feasible, complementary interviews were undertaken with industry individuals with specific expertise in key areas to supplement findings. Overall over **29** stakeholders participated in hindsight review meetings and **3** individual interviews were held.

Further information for each case study was collected, through site visits, desk-based research and via evidence contribution from project teams (drawings, photos etc.) of Best-Practice methods and, where possible, evidence of energy benefits and actual costs. The list of evidence contributed and reviewed is detailed in **Appendix A-6.** When the case study approach is applied to a small number of cases, this allows for the uniqueness of each individual case to be explored (Patton, 2014). A cross-case comparison was then carried out to identify patterns that appeared to have a bearing on outcomes. This evaluation covers both the process of the project (e.g. what was done and how well it worked) and the impacts of the project (e.g. what difference did the project make).

Table 12 Overview of sampled projects

Project	Location	Funding	Size	Deployment	Household types	Property types
Slough Borough Council	Slough: Slough, Langley, Cippenham, Priory Britwell, Winvale	ECO/ Council funding	680	Mass-Area/Estate-based	Mixed tenure, predominantly social housing with leaseholders	Mixed with large number of non-traditional (BISF, WNF) homes
Haringey Smart Homes	London: Haringey, Camden, Enfield, Islington, Waltham Forest & Hackney Councils	GDC/ECO /Council funding	1276	Street by street/ pepper-pot	Mainly private sector owner occupiers with PRS/landlords- including both single family & HMO properties	Georgian, Victorian terraces/semi-detached. Low rise blocks
Bristol City Council Green Doors / GDC	Bristol: Easton, Horfield, Totterdown	GDC/ECO & EU funding ELENA/ LEAF	2234	Street by street	Mainly private sector owner occupiers	Georgian, Victorian terraces/semi-detached.
Greater Manchester Combined Authority Little Bill/ GDC	Manchester: Cross Borough including Wigan, Stockport, Rochdale	GDC/ Council funding	1302	Street by street/ pepper-pot	Mainly private sector owner occupiers, many on low incomes	Georgian/ Victorian terraces & non-traditional constructions
Nottingham City Greener HousiNG	Clifton, Lenton Abbey, Bilborough, Sneinton (Windmill Lane), Aspley	GDC/ECO / Council funding	1100	Street by street/ pepper-pot	Mainly Mixed tenure, mostly social housing sector with private included	Blocks of flats with over 20 different archetypes overall covered

3.2 Slough Borough Council Retrofit Project

The key findings from this project are

Best-Practice and quality

- A thorough 'multiple-layer' QA process which encompassed both internal and external QA processes was implemented in the project.
- The client required a consistent approach implemented through a contractor who was both highly familiar with the products used and 'site savvy' to deliver a high-quality installation that carefully considered both Health and Safety and CDM requirements.

Costs, impact and opportunities for economies of scale:

- The total costs of the project varied considerable based on the nature of the stock in each of the six areas targeted (between £11,000 – £160,000 in one area).
- The project adopted a best value approach which considering cost using a longer term lifecycle approach, factoring in not only installation costs and the proportion of grant funding available, but also maintenance costs (30-year lifespan).
- An opportunity for significant cost saving is the careful planning and use of scaffolding for various installations when possible. This accounted for up to 25% of costs and was enabled through co-ordination of contractors as well through careful planning by the council.
- The main element impacting costs was the enabling structural works required for the non-traditional properties to allow for the EWI to be installed (which varied by property in the range of 5-10% of the total cost). This was an upfront cost that was not covered under available grants.
- Since a significant number of properties which would benefit from EWI are non-traditional it would be key the future grant policy take this into account and possibly include this.

i. Overview

This Slough Council project is a large-scale retrofit that aimed to deliver measureable improvements, both aesthetic and environmental, to approximately 680 mixed tenure properties across the six sites (Slough, Langley, Britwell, Cippenham, Priory and Winvale). The sites included six different construction types (including non-traditional properties), for both single and multi-family properties (low rise, three storey blocks of varying size). The completed works were carried out across 2 phases.

The holistic approach utilised in this project aimed to showcase the added-value of EWI, beyond the expected energy savings, through installation of EWI as well as associated works to all the properties, communal areas and external landscaping.

The main constraints of the project were to assure that the properties were suitable for a 30 year-assured life guarantee, ensure efficiency benefits to the end-user and improve the aesthetics through developing the street-scene to move away from a 'council estate look (**Figure 13**). Additional aspects considered include such elements as program, quality and costs – all which are considered as standard requirements on these project types. Further to the costs constraints, the client also required that the annual carbon reduction targets (determined at Borough level) were achieved as part of the programme.

The programme was funded through a mix of council and government grant funding, the levels of which changed throughout the project. The government grant funding was predominantly ECO. During the first phase, a GDHIF cashback funding element was also sought (approximately £6,000 through the contractor) when available for the privately owned properties which constituted about 20% of the stock that was retrofitted.

Figure 13 Examples of the EWI works carried out as part of the project in Britwell (right) and Langley (left)
Source: SERS, 2015

ii. Analysis and Findings

Retrofit Strategy:

This project encompassed six different construction types. This included hard-to-treat solid walls and non-traditional properties- both concrete and steel construction types (BISF, Wimpey No-Fines, CFRAM and SNW flats, bungalows and houses). The first phase of the project included non-traditional construction properties, Best-Practice from this perspective therefore aimed to ensure that the structure of these properties was sufficiently sound to support EWI and which would in turn be maintained through the installation of EWI to extend property lifespans for a further 30 years. From a technical perspective, these enabling works were in most cases the more challenging aspect of the EWI works (see example of BISF house solution in **Figure 14**).

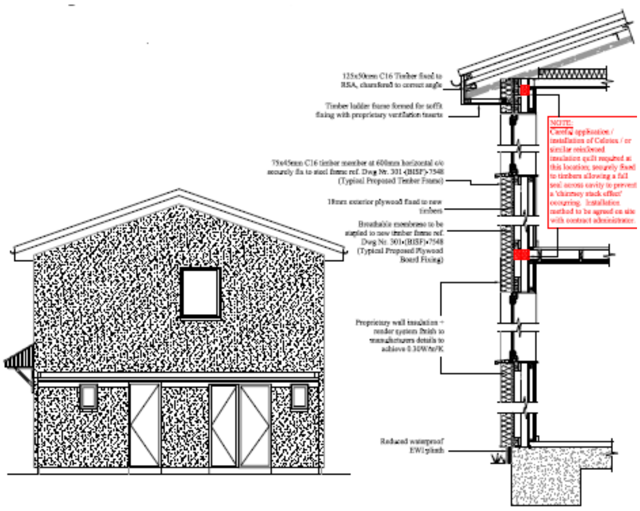


Figure 14 Retrofit strategy specification (including structural enabling works) for a British steel framed house (BISF) variant on the project. Source: Michael Dyson Associates, 2017

The base insulation material used was a 90mm EPS board (Envirowall), with pebble-dash render, brick slip, brick effect render and mineral texture finish options. The EPS boards were installed using dry mechanical fixings, with no adhesives. The finishes and designs varied to accommodate the circumstances of the each of the house types on an estate by estate basis. The material specification was based on a consultation with the consultants guided by a target U-Value of 0.28 $Wm^{-2}K^{-1}$ set to achieve a required uplift in thermal benefit as well as to meet EPC and ECO criteria. Different materials, finishes and colour schemes were considered and a suite of samples was delivered. This was primarily to achieve aesthetic variety on the different estates rather than for technical reasons.

The EWI installation was future-proofed through including measures such as the upgrade/ installation of communal satellite dishes, providing information and introducing changes to leasehold clauses to prevent damage to the facades. Although this was an extra cost, it both benefitted the residents and was viewed as a measure that could help mitigate expensive future repairs.

Installation and Deployment:

The client required a consistent approach implemented through a contractor who was both highly familiar with the products used and 'site savvy' to deliver a high-quality installation that carefully considered both Health and Safety and CDM requirements. A single contractor undertook the works, both directly employing and sub-contracting out to specialist parties when required (e.g. repair work on non-traditional housing). The sub-contractors had a long-established relationship with the contractor and long-term experience with EWI installation.

This set-up avoided the client having to put in place new procurement processes and orders as well as avoiding project managing a multiple invoicing scheme. In addition, this also allowed the lead contractor to have complete control, from a management perspective, on site. Due to the nature of the project, significant co-ordination was required throughout the project lifetime from the initial repair work, to the costing and procurement.

The deployment approach was predominantly area-based with street-by-street (estate/sub-area) installation. However, a pepper-pot approach was used in some instances to allow for the repair work required following the inclement weather. The pepper-pot approach was also used to overcome planning issues, where planners required that the EWI be installed on some (originally red-brick blocks) before wider deployment was permitted. This necessitated a negotiation process where different options were considered by parties until a cost-effective finish (brick effect render) was approved for use by planners. The mass deployment was facilitated by the installer setup, who had moved their manufacturing base back into the UK. It should be noted that while the manufacturer was able to provide 'house-packs' through their depots to also support single house installation, this was not viewed as a favourable approach as it was not always a highly co-ordinated process.

Quality Assurance and Inspection:

A thorough 'multiple-layer' QA process was implemented in the project which encompassed both internal and external QA processes. All properties were subject to a pre-install survey which highlighted remedial works required as well as opportunities for combining programmed works and subsequent cost efficiencies. Following this, project cycle key stage QA inspections as well as ECO guarantee inspections (including the de-risk elements during the latter phases, which involved evidence submitted with timestamps and GPS information attached) and BBA inspections of 10%-15% of properties. Both the contractor and manufacturer implemented an inspection regime which included walk-arounds with site personnel, reporting and collecting photographic evidence of issues observed and subsequent corrective actions taken.

In terms of information provision, a thorough audit trail was established through the contractor's 9 -stage QA schedule, to support both internal QA and the satisfaction of ECO guarantee requirements. While the QA processes and record keeping required were somewhat complicated and onerous, the existence of information on the de-risk platform allowed for the retrieval of key information when an issue occurred with contractor archives as well as providing secure information that could be employed when investigating (fraudulent) claims. The extensive requirements were also seen as perhaps an especially important requirement for schemes where competence and experience might not be at a high level or where transient workforces were the norm.

It should be noted that a key element of QA required that the EWI was not only inspected from an insulation perspective, but was also inspected from a structural perspective as it also acted to protect the structure. The EWI was insured with a dual warranty arrangement to meet internal requirements, this included a 30-year installation warranty and a materials warranty. Information provision through industry guidance to address issues such as detailing to prevent cold-bridging was highlighted as a key aspect that should be considered. The ventilation detailing 'traffic light' system was regarded to be especially effective when used to discuss various approaches with clients, and highlighted the risks and costs involved with each.

Training was available via the manufacturers, through an off-site programme (at training depots) and an installer carding scheme involving on-site inspection of installation practices. The contractor was also able to action the requirements for the local labour initiative (required by the client) through partial apprenticeships and employment.

Occupants and Community:

The property occupants included both social housing tenants and private leaseholders, who in general often have conflicting views and priorities regarding EWI installation. In general, leaseholders are likely to be more wary and likely to oppose works due to the costs involved while tenants tend to be more in favour as they do not incur costs (beyond a minimal rent increase) and are likely to benefit from decreased fuel bills. However, leaseholders tended to be more engaged in the process due to the financial cost this incurred for them (a £10,000 contribution cap per leaseholder was put in place irrespective of the cost).

The group had previously highlighted that in the past, works and repairs to the buildings often only replaced like-for-like, which was not viewed as not beneficial. Consequently, as leaseholders were required to contribute to these works the leaseholder-specific customer value proposition aimed to demonstrate relevant benefits and the significant added-value to the properties through the EWI works and additional installations (free boilers…etc.). The potential increase in property value was a main driver for leaseholders (established by some independent valuations undertaken by leaseholders), this also simultaneously increased the council's asset value base.

The client aimed to give all occupants as much opportunity for consultation and contribution to decision-making as early as possible and as much as possible in conjunction with the planning requirements. All groups were engaged through face-to face consultation meetings that included a representative from each of the project team organisations to provide a 'full picture' of the process. These meetings, held before the contract started, included demonstration of examples of the selected product finishes (full scale mock-ups) to be used for feedback. As the meetings were in general not highly attended (10% attendance) follow-up letters were sent detailing the information discussed.

Satisfaction with the liaison arrangements was employed as a KPI on projects undertaken by the council. Although a dedicated council tenant communications post did not exist, several liaison points were put in place. This included a client liaison officer from the council and a contractor-appointed liaison officer who acted as a go-between to address any arising on-site issues. The liaison officers were local to the area and were viewed as key in the success of the project throughout the stages from initiation to handover, especially in resolving access issues.

As an extension of their duty of care, the consultation process also helped the council identify tenants who had other needs and refer them to appropriate departments for additional support. The local labour initiative meant that local labour was employed and money spent locally to drive the local economy. Councillors were engaged in this process, particularly at the time when local elections were being held, to enable increased 'buy-in' from occupants and ensure that councillors had the information required to respond to any arising queries.

Funding and Cost Effectiveness:

The total costs of the project varied considerable based on the nature of the stick in each of the six areas targeted. The average cost for key project areas are summarised below (**Table 13**).

Table 13 Average costs of EWI installation and associated works for key areas with Slough Borough Council

Area	Project Value	No of units	Average cost per unit
Britwell	£1,600,000	12 low rise blocks of flats	133,000 per block
Langley	£2,400,000	15 low rise blocks of flats	160,000 per block
Slough	£4,000,000	360 various house types	11,000 per house

The project adopted a best value approach (which should not be confused with the 'cheapest option'). This involved considering cost using a longer term lifecycle approach, factoring in not only installation costs and the proportion of grant funding available, but also maintenance costs (in this project over the 30-year lifespan) as well as the long term benefits of the project to the residents. This more holistic approach to weighing the relative cost/benefit of decisions was viewed as more sustainable. For example, replacing the flat roof with a pitched alternative in one of the project sites was not only to improve the look of the building, but was also in part to remedy the poor quality of the flat roof and allow easy maintenance.

The cost viability of the scheme was based on the client receiving a certain level of grant funding. The initial funding was secured through both government grant schemes (15%-20%) and Council funding (where a capped limit had been identified). The consultant provided advice as to available sources following a review of potential schemes. In general, grant funding was viewed as being quite restricted as it did not take into account the add-ons associated with EWI or retrofit in general that are required to get to the end result.

Since then, the grant funding available has been reduced (5-10%), however since a precedent had been set in recognising the benefits of the works to the end-user as well as meeting the carbon reduction targets, the decision was made to maintain the works and continue rolling out the programme even with reduced grant funding. As previously mentioned, GDHIF was sought during the first phase for the privately owned homes, when this was no longer available, it became more challenging to market the works to the private owners. Works however (funded through the council) were still carried out in the second phase to the leasehold properties within the mixed tenure block.

The main elements impacting project costs include:

- **Enabling structural works:** Non-traditional properties were not built to last for a significant amount of time, they do however provide the council with housing required to meet demands. The remedial structural works to the non-traditional properties to allow for the EWI to be installed (which varied by property in the range of 5-10% of the total cost) had to be found as an upfront cost, even if it was not covered under available grants. Since a significant number of properties which would benefit from EWI are non-traditional it would be key the future grant policy take this into account and possibly include this.
- **Inspection costs:** Another key cost consideration was the undertaking of inspections to prevent defects that would require significant funding to address in the future (e.g. repairs to verges and sill and addressing cold bridging and ventilation issues).
- **Finishes:** EWI EPS boards are quite lost cost in themselves (approx. £12 per sqm.). Material cost variations are often due to different materials which can elevate costs. For example, brick slips finishes can triple costs compared to a render finish. The area unit (per sqm.) cost often used by industry was not viewed as a helpful metric as it does not reflect additional elements required (which can double the costs) and labour/skill levels and time required for the various finishes. This metric might also deter stakeholders from including these essential works and may therefore impact the quality of installation.

Cost certainty was an important issue and was supported by a number of cost plans (produced by the consultant) before the project started. Cost variations were as a result of unforeseen elements (e.g. asbestos, number of boiler replacements) that could not be approximated before gaining access to all properties rather than cost rises in EWI contracting, material quantities or the minimal design changes required. As mentioned, available grant funding does not normally take into account aspects such as this. Since the boiler replacements were originally often not due to be carried out for a number of years therefore the client had to reallocate money to meet these associated costs. Due to the organisational structure of the council, this was not a straight forward process and required effort on the part of the client to action this effectively.

The major elements in the EWI costs are enabling, material costs, scaffolding and access to carry out the works. The initial contract would have included an approximate 40% labour/ 60% materials breakdown. Scaffolding contributes as much as 25% of costs especially on blocks of flats

The main opportunities to achieve cost reduction (provided that an adequate number of properties are targeted) include:

- **Scaffolding:** One of the key aspects highlighted as an opportunity for significant cost saving, was the careful planning and use of scaffolding for various installations when possible (EWI, windows…etc.). This was enabled through the co-ordination of contractors as well as careful planning by the council. In this instance, the pre-installation survey highlighted that window works due to take place in the future could be moved ahead to make use of the scaffolding being in already place for the EWI works. The council was able to reallocate funds to enable this and was therefore able to undertake the window replacement works at a lower cost.
- **Experienced teams:** The use of experienced teams and provision of training, although a high outlay was considered a key element of the best-value approach used in the project. This was complemented by the appointment of a single contractor with the necessary skills and delivery capacity as the main interface, the appointment of a multi-disciplinary principle designer/contractor to take on responsibility at an appropriate level and the use of a collaborative contract format (JCT).
- **Standard specification:** The provision of standard specification for material and installation provides scope for cost reduction at scale, particularly from a repair perspective. However, due to variations in properties, the implementation of standard specifications was not always possible. The production of standard terms and conditions by the client which may be easily used on other projects, was also considered an example of standardisation that could significantly reduce costs and time.
- **Stockholding of materials:** The ability to stock-hold and provide continuity in supply for an extended period by the installer was viewed as key. Having a centralised base within the area for supply and installation also significantly reduces travelling time.

3.3 Haringey Council Smart Homes

The key lessons from this project are

Best-Practice and quality

- In terms of EWI measures, the approach adopted for this scheme was mass rollout with support for 'bespoking'.
- As well providing valuable technical support, the Smart Advisor role (although as a high upfront cost) led to significant cost savings in terms of providing independent technical oversight, cost policing for contractors' quotes, communication with customers and auditing. It is an especially key role for private owners and landlords where a liaison officer role may not already exist.

Costs, impact and opportunities for economies of scale:

- Collaboration between Haringey staff, the Smart Advisors and quantity surveyors led to the development of a set of benchmark rates for different areas of insulation, varying insulation materials and miscellaneous items. This schedule of rates helped to overcome the issue of high variability in pricing (up to 120%) and different methodologies to accounting for various enabling works
- As the only London-based project reviewed in this study, this project highlighted the significant impact of construction costs in London as well as the practical challenges to installing in the city that add to costs. (e.g. parking issues, planning consents and other logistical issues)

i. Overview

Haringey's DECC/BEIS funded Smart Homes Project started in late 2014. The project was set up as a six borough partnership, where Haringey Council had previous experience on a DECC/BEIS Green Deal Pioneer project to investigate its ability to become a Green Deal provider. The partnership was due to a requirement to deliver retrofit at scale (three + boroughs), and was as a result of a geographical close link between Haringey, Camden, Enfield, Islington, Waltham Forest and Hackney Councils. Furthermore, the similarities between the housing stock in each borough, which would support scale delivery and procurement efficiencies due to access to the much larger market (**Figure 15**), was another key incentive for this collaboration.

The project primarily aimed to target owner occupiers who were able to pay for measures, the private rented sector and businesses. A range of house types (Victorian, Edwardian…etc.) including both single family as well as HMO properties and blocks of flats were included. This resulted in a total of 1276 delivered installations, 66% of which included EWI, which exceeded initial delivery estimates. The project set out to test innovative measures to deploy EWI through working with community groups, installers, and through the local authority with the aim of developing knowledge and setting up a 'one-stop-shop' council led advice line for homeowners in regards to the process and measures available.

A key innovation was the introduction of a crucial retrofit Smart Advisor role responsible for technical co-ordination/oversight with a technical/surveying/architectural background to support both the customer and installer. The Smart Homes project showcased the role and potential contribution of Smart Advisors (Retrofit Co-ordinators) to the process through three main roles (The Retrofit Academy, 2016):

- Management: Undertaking the role of a construction project manager, where required, to ensure delivery on time and on budget.
- Coordination: Providing informed advice and support to contractors and consultants to help foster understanding and teamwork amongst stakeholders.
- Quality assurance: Providing assurance to retrofit clients so that the project risk is managed.

The professional development training programme undertaken by Smart Advisors through the Retrofit Academy, aimed to provide individuals with key skills in the area of domestic retrofit coordination and risk management with the aim of adding value to clients.

Figure 15 Boroughs participating in the Smart Homes Project. Source: CAG Consultants and Changeworks, 2016

ii. Analysis and Findings

Retrofit strategy:

The project initially started with the main focus on the delivery of technical and financial support for wall insulation. As the project developed, it increasingly focused on the delivery of EWI alongside other 'softer' measures. This was due to the lack of appetite in the market for EWI as a stand-alone measure, the lack of knowledge amongst residents as to its benefits and associated hassle factor (requirement for planning…etc.). The softer measures option was also introduced to address contractor concern around the initial limited turnover of work.

In terms of EWI measures, the approach adopted for this scheme was mass rollout with support for 'bespoking'. Therefore, to allow for customer choice as described in **Figure 16**, the council were not prescriptive in regards to materials that could be used. Consumers were supported by a Smart Advisor role undertaken by trained individuals (form ECD Architects) with an architectural knowledge base to advise on the materials and ensure installations complied with set requirements. It should be noted that the Smart Advisor had limited input in advising the customer of cost due to Financial Conduct Association (FCA) rules around this.

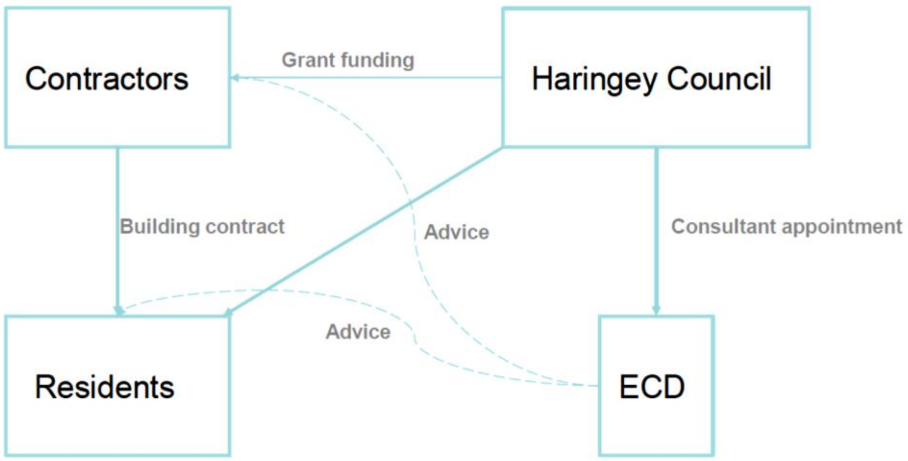


Figure 16 Roles and responsibilities on the Haringey Smart Homes Project. Source: Traynor et al., 2016

Installation and Deployment:

The insulation strategy was initially based on the customer journey that started with a consultation with the Smart Advisor. During this, customers were given information regarding the relative requirements, characteristics, and benefits of natural versus synthetic materials and subsequently the freedom to choose.

Following initial implementation, this was reconsidered as the provision of extensive information too early in the process often leading to confusion for some occupants. The revised journey first started with the Green Deal assessment and quotation, followed by the Smart Advisor consultation where customers were free to select but did so based on their awareness of funding limitations and their specific requirements.. This was viewed as a more successful approach. The system and process was subsequently left to the discretion of the installer and homeowner. As previously mentioned, while Smart Advisors did not provide financial advice, their role was did involve reviewing costs against benchmark schedule of rates once the resident had approved the quote

The installation was undertaken through the following two distinct mechanisms:

- The **procured route** was through the lead contractor - InstaGroup - working in partnership with six Snug Network contractors and a network of suppliers under that. The procured route was mainly based on contractors with CESP/CERT experience who had not extensively dealt with private homeowners on an individual basis. This led to challenges in turn-around times and customer relationships. This, at times, resulted in Haringey Council taking on a ‘contract management’ role to ensure customer jobs were managed efficiently to resolve issues and ensure that works were on track.
- The **independent route** extended the network of suppliers to about 30 in total, which included both larger suppliers and smaller SMEs. All independent installer were required to have the appropriate Green Deal Accreditation to take part in Smart Homes. The SMEs were largely local and more responsive to complaints, and considered to be a more trustworthy. As occupants viewed them to be a more positive alternative to larger providers and more flexible to project changes, they were considered as a more favourable option for many homeowners.

It should be noted that InstaGroup manufacture their own (largely traditional) high embodied carbon materials, however due to the historic nature of the stock customers often preferred natural materials with lower embodied carbon and therefore opted for the independent route.

All installers were required to follow a standard approach to improve the specification of building details, reduce unintended consequences and avoid locking in problems that may affect future works.

The initial requirement of the funders, DECC, highlighted that a street-by-street approach should be adopted however this was extremely challenging in London due to the lack of information on occupants, and the challenge of securing buy-in from all parties involved given the limited programme delivery timeframe and differing timing on decision-making. Due to the approach and market targeted, the mass roll-out delivery was therefore necessarily pepper-pot rather than bulk installation, with the option to bespoke measures. Due to the sequencing of the project, installations were carried out over phases. The first batch in effect served as opportunities for iterative self-learning which then improved the following stages.

Quality Assurance and Inspection:

In terms of QA, installers were required to undertake pre-installation meetings and pre-installation surveys, however these were mainly focused around the undertaking of the Green Deal Assessment. Installers were also required to follow the PAS 2030 process. In addition, to ensure higher quality installations, Haringey together with Smart Advisors drafted and developed a Smart Homes Standard Approach Document. This in effect served as internal QA, setting a standard installation approach for solid wall insulation and outlining guidance for the building elements listed in **Table 14**.

Table 14 Key guidance covered in Smart Homes Standard Approach

Window and door reveals
Ventilation
Verge trims and eaves i.e.: capping insulation
Suspended floor insulation
Window sills
Base details i.e.: insulation below damp proof course

Further to this 10% audits across the range of installers were undertaken by the Smart Advisor. These flagged up some common defects which the installers were required to address in installations through improved specification.

Each delivery company had a lead person/foreman on site. However, due to initial challenges with delivery, the overall project management (with the exception of on-site operations), was largely undertaken by Haringey through consistent follow ups via weekly calls and reports from contractors. Any major issues would be dealt with by Haringey and the relevant contractors and information would be cascaded to relevant parties for resolution. Finally, there was a requirement for the Smart Advisor to revise the quotes provided to ensure they met specific criteria defined in a checklist as well as following a standard approach and, the relevant PAS 2030 and BBA requirements.

Occupants and Community:

The project aimed to target owner occupiers who were able to pay for measures, the private rented sector (landlords) and businesses. The grant required a 25% contribution level[9], which precluded many residents in fuel poverty or vulnerable households.

In terms of recruitment, some targeting of occupants was undertaken based on council housing data and a virtual Google-Maps based assessment of potential streets or areas where uptake would be higher. A targeted Councillor letter (signed by the Councillor in each borough) was sent to occupants. This played a vital role in recruiting customers, as a personalised letter and involvement of a local authority were viewed as being crucial in purveying quality and establishing trust and accountability. The central offering of a ‘better, greener, warmer’ home (**Figure 17**) showcased not only energy saving benefits of EWI, but further potential benefits and appealed to three sectors within the target market:

- Better: Homeowners who values the appearance of their property,
- Warmer: Older people who valued thermal comfort,
- Greener: Occupants with environmental awareness, the trailblazers.

Following the targeting stage, interested homeowners then called a dedicated advice line. This was set up as a first point of call to answer queries from prospective customers, refer them to an installer and, later, to also manage any issues (and address them) due to the installation process. A self-generation route was piloted with a number of installers. This led to a number of homeowners being recruited via adverts or word of mouth. This worked particularly well in the private rented sector as landlords had existing trusted relationship with installers with PAS 2030 accreditation.

[9] This contribution level was set following a ‘trial and error’ process where initially the customer contribution was linked to the Green Deal’s ‘Golden Rule’. This proved difficult to communicate clearly to potential customers and meant that contributions varied for each household. The offer was subsequently adapted for all property and tenure types to the 25% contribution level. This revised offer was considered to be simpler to communicate to customers and overcame the challenges of explaining the Golden Rule. Customer take-up levels rose significantly once this offer was in place (CAG & Changeworks, 2016).

Figure 17 The Smart Homes logo. Source: CAG and Changeworks, 2016

Within this context, the softer measures offered were in effect regarded as a route in, where following the undertaking of an assessment and subsequent discussion of options there was more of an opportunity to include EWI. In reality the occupants who had opted for the EWI package tended to be ‘leaders’ who had previously undertaken energy efficiency works. The softer measures led to a snowball effect and enabled positive word of mouth and high visibility to act as a catalyst to encourage further uptake in the boroughs and enable the scale up.

A mixed tenure block of 38 units (**Figure 18**) was highlighted as a success story. Despite the challenges in delivery the project was delivered by the resident’s cooperative and benefitted all residents – some who would previously have been in energy poverty.

Before **After**

Figure 18 The impact of retrofit on the Haringey mixed tenure block. Source: Traynor et al., 2016

Funding and Cost Effectiveness:

The funding structure was based on both DECC/BEIS funding in addition to ECO funding. The ECO funding element included a preferred supplier (EoN), who the homeowner was not obligated to use, and involved an additional set of paperwork. The council was initially required to sign up a target number of occupants for the Green Deal loan scheme. However, there was a lack of clarity as to its financing, the Golden Rule and any subsequent benefits. Subsequently, this was replaced by a more simplified and ‘strong’ grant offer with a clear 25% contribution from the owner, which was in particular key for recruiting both homeowners and landlords:

- Option 1: £6,000 grant + 25% contribution included EWI in addition to another measure. Following feedback from the occupants in regards to improving the scheme received during discussions via the advice helpline, offer 2 was subsequently developed.
- Option 2: £3,000 + 25% contribution included other softer measures such as boilers and window replacement. Option 2 was ring-fenced to limit a certain number of measures to ensure that the EWI focus was maintained.

The Green Deal Assessments were part funded by the council who match funded the £50 owner contribution and the calculation of the Smart Homes grant payable is as follows:

Smart Homes Grant = Total cost of eligible works inc. VAT – (Householder Contribution + ECO grant where available)

The domestic grant funding element of the scheme was £5,426,591 and a total value of £7,875,000 of energy efficiency works were carried out in private households across the six boroughs (comprised of public funding and applicant contributions) (CAG Consultants and Changeworks, 2016). The average capital cost of all measures across the project was £4,252 (based on the grant funding element of works). The impact/cost effectiveness of the project through key indicators, is summarised below (**.**

Table 15).

Table 15 Cost effectiveness indicators of the smart homes project. Source: CAG and Changeworks, 2016

Indicator			
CO_2 savings	Average annual CO_2 savings per household (tonnes)	Total annual CO_2 savings (tonnes)	Total lifetime CO_2 savings (tonnes)
	1.02	1,303	42,338
Energy bill savings	Average annual financial savings per household	Total annual financial savings	Total lifetime financial savings
	£222	£283,386	£9,226,491

The cost per tonne of CO_2 saved for the Smart Homes programme is estimated to be £128 per tonne CO_2. This is based on the total capital costs for the domestic grant funding element of the scheme (£5,426,591). Based on previous lessons learnt, the installation cost funding was administered directly through the council to avoid issues with disputes. Payments were released to contractors after occupants signed a declaration stating their satisfaction with the completed works and a required set of documents were submitted (e.g. Declaration of conformity, post installation EPC, final schedule of works…etc.).

Smart Homes attempted to develop a schedule of rates. This was challenging across a network of 30 installers each of whom had different methods of pricing works. However, collaboration between Haringey staff, the Smart Advisors and quantity surveyors led to the development of a set of benchmark rates for different areas of insulation, varying insulation materials and miscellaneous items. This schedule of rates helped to overcome the issue of high variability in pricing and different methodologies to accounting for various enabling works (e.g. scaffolding) in the quotes.

The indicative schedule of rates was based on specific ‘pricing methodology’ where an estimate of the price variance of a unit area of insulation which also considered auxiliary works and economies of scale when a larger area was installed was provided. In general, this methodology can be used as the basis for a ‘cost calculator’ that may potentially provide a more realistic and consistent ball park figure than those currently being used.

The indicative cost included a margin of flexibility and served as a benchmark for Smart Advisors to query contractors when costs seemed higher than expected. The Smart Advisors evaluated the cost of works and the level of detail provided in schedules of work. In instances where quotes were in excess of benchmark rates, this led to discussions with installers to identify possible reductions in material costs or discuss in more detail the risks identified in the technical report. Where no cost reduction was possible, installers detailed the reasons why costs were in excess of the benchmark. Reasons for costs above the benchmark included: replacing boiler exhaust flues, scaffolding and complicated architectural features. With the support of the Smart Advisor, this led one contractor to revise a quote which was originally 120% over the general rate without a specific reason.

The main elements impacting project costs include:

- **The Smart Adviser Role:** An issue with the Smart Advisor role (£200-300 per home) was the high cost and budgeting constraints resulting from current HM Treasury categorisation of the role. The role had initially been specified as part of the 90% capital portion of the budget, whereas due to HM Treasury rules it was defined as being within 10% revenue thus eating out a significant proportion. This significantly impacted the project as it limited the budget available to carry out more targeting and increase marketing.
- **Hidden costs:** Initial grant modelling vastly underspecified the costs, this grant level was revised following feedback to account for hidden costs (e.g. parking for non-local contractors, planning application costs, access issues with the congestion charges in inner boroughs…etc.) this provided more cost certainty in terms of estimates and numbers of customers.
- **Planning delays:** Planning was an important challenge/ road block in the process, particularly given the involvement of six local authorities. The ambiguousness of Permitted Development across LAs was highlighted as significant factor, where substantial time delays could happen as a result of the requirement for full planning applications (often on a bespoke basis) and the information required. Haringey Council produced guidance on the information requirements to guide them, however this was not considered at the start of the project. A similar guidance document with joint consensus/clarity by both BEIS and DCLG (and trickled down to boroughs) needs to be put in place to support mass rollout of EWI.
- **London-based costs:** The construction costs of installing measures in London are higher than the most of parts of the UK, and there are also practical challenges to installing in London such as parking issues, planning consents and other logistical issues that add to costs.

The main method to achieving significant economies of scale is by having a large cohort which could be taken as a package to procurement. This is probably more viable in situations where a large group of properties are under the same owner ship and co-located to some extent. However, when targeting a private sector market, clustering maybe achieved via a phased approach and increased marketing, and a long term technical and financial support package.

The main opportunities to achieve cost reduction (provided that an adequate number of properties are targeted) include aspects such as:

- **Informed targeting:** The targeting adopted in this scheme was in general reactive to the limited one-year programme delivery time-frame and was viewed as an area of potential improvement/refinement and testing for future work. Prospective customers often changed their minds due to differing opinions within the household and a lack of sufficient information as to the hassle factor involved in EWI installation. Differing timing on decision making was also a key factor in the more piecemeal approach (as opposed to bulk) to deployment/installation. Therefore, marketing should account for 5-10% to target and recruit the right occupants to ensure that the contractors' time is not wasted and avoid dead end leads.

- **Smart Advisor Support:** Although the cost was high, it was considered to be a worthwhile cost which led to significant cost savings in terms of providing independent technical oversight, cost policing for contractors quotes, communication with customers, auditing etc. It is an especially key role for private owners and landlords where a liaison officer is not provided (as with the social sector). This role is now being supported by the Retrofit Academy and can be in effect be viewed as a 'liaison-light' role.

3.4 Bristol City Council Green Deal Communities

The key lessons from this project are:

Best-Practice and quality

- Short planning timelines, due to funding schedules, led to missed opportunities to carefully consider all aspects of the project and put in place adequate measures to allow for more targeted roll-out and benefit from subsequent economies of scale
- The intended street level engagement and roll-out aimed to target possible economies of scale and reduce individual disruption due to difficulties with the delivery partner, however practical constraints led to a reactive pepper-pot deployment approach.

Costs, impact and opportunities for economies of scale:

- The budget for the BCC project was based on a number of funding schemes. A financial model was developed by the Programme Manager to deliver the scheme within the boundaries of the Green Deal structure.
- The main elements impacting costs were the remedial works carried out on projects where contractors went into administration and for works that were done improperly.
- The main opportunities to achieve cost reduction include a more informed and managed decision-making process where a stricter time-limited offer to customers would ensure that the level of occupant sign-up required to enable a more mass approach to deployment would be supported.

i. Overview

The Bristol City Council (BCC) project, a Green Deal Communities project (GDC), employed very clear criteria regarding properties to be included. Subsequently the project aimed to target Hard to Treat homes, with occupants who were Hard to Reach. In BCCs view this was translated into solid wall properties and generally private rental sector occupants as well as people who do not 'fit onto the radar' in other ways (e.g. fuel poor or do not engage with energy efficiency schemes). This particular project captures the value of Community Energy Partners (CEP) in wider scale consumer recruitment, engagement and bringing added-value and benefits to the community as a whole.

As the GDC set-up encouraged aiming for an area-based 'focused' scheme, in Bristol this translated into the inclusion of three wards (Easton, Totterdown and Horfield) within the city with high incidence of solid wall properties, with different demographic profiles (deprived, medium and high-income wards) (**Figure 19**). The initial plan put into place by BCC therefore targeted work across these three wards with an option of an established Community Energy Partner (CEP) in one, looking at establishing a new CEP in another and no CEP in the third. This approach aimed to compare and assess the impact of having CEP in terms of driving engagement and sales across wards.

It should be noted that private rental sector tenants were included in the initial GDC application however, following consultation with DECC/BEIS, a Private Rented Sector (PRS) scheme was developed into an independent application as a pilot. Within some of the wards, the councils had decided to set up a licensing scheme for landlords, if issues were identified, landlords were referred to this schemes as a possible measure to address them. A Hazard Home Rating system was used to highlight potential properties. There were mixed tenures across wards, but social housing was not included.

Following delays in November 2014 and several rounds of amendments, DECC/BEIS required an increase in numbers of installations carried out for it to be considered value for money. This was not viewed as a positive outcome as BCC had undertaken robust financial modelling in regards to their properties and potential uptake, therefore believed that their initial estimates were more realistic. Nonetheless BCC increased the delivery target to enable access to grant funding and in total 2234 properties were included (1600 for the regular scheme and 686 for the PRS). The total grant funding allocated was £7.2M. BCC also insisted that GDHIF would only be promoted to customers if they viewed it as being the best option for them.

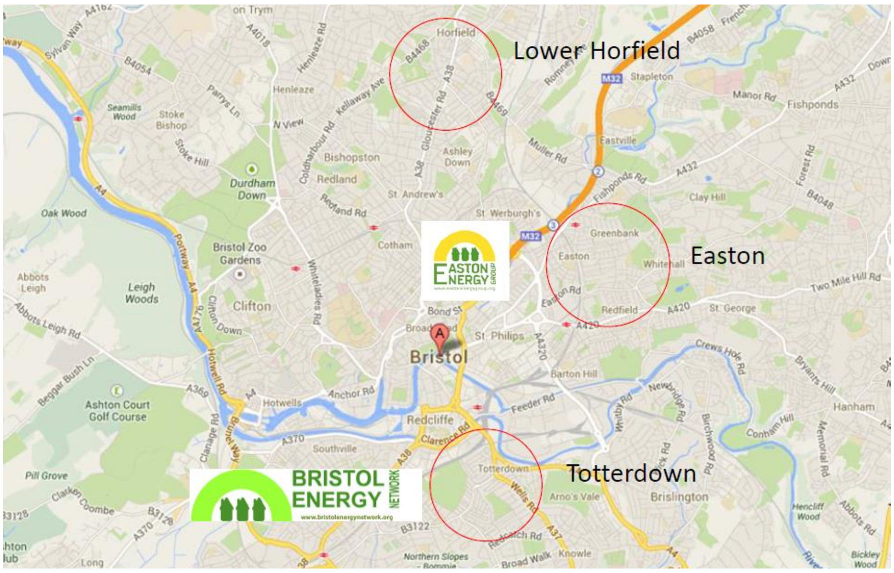


Figure 19 Bristol City Council target areas. Source: Snolder, 2014

ii. Analysis and Findings

Retrofit Strategy:

The scheme included both show homes as well as a network of competition winner homes, where work would be initiated, to act as champions and exemplars. The insulation strategy in theory offered unlimited options to customers, and the show home had different options for customers to view. However, in reality unless customers specifically requested otherwise, EPS was used. In addition, regardless of customer requirements, the delivery partner narrowed down choices to the range they wanted to work with or had already procured. Thus what was offered in the show home and what was delivered were viewed as separate things. The Sustainable Traditional Buildings Alliance (STBA) were brought on board by BCC to produce Best-Practice Guidance on SWI for traditional buildings specific to Bristol with an online tool and design drawings included as well as follow ups for the pilot training courses.

Easton Energy Group/ Bristol Energy Network were appointed on help to focus locally on Easton as part of the GDC and to help the council with setting up a new community energy group in Totterdown to support local residents to undertake retrofit and disseminate learning from the projects across the city. A main focus of their work was community engagement and support.

Installation and Deployment:

Procurement had to follow OG rules as it exceeded the £4M threshold. Given the GDC timelines, inadequate time was devoted to planning the tendering process in terms of exact requirements. A negotiated tender was put in place rather than the standard ITT. This helped to expedite the process, offered various options and enabled the council to focus on the social aspects with the aim of adopting a more holistic approach.

The scheme originally had one delivery partner-Climate Energy-who were initially expected to manage the scheme from door-knocking to invoicing and was responsible for the allocation and phasing of installation work. The partner then appointed contractors (and sub-contractors) to carry out the installations. They were managed by BCC who worked alongside Easton Energy Group and Bristol Energy Group as engagement partners as well as Streets Alive, an organisation specialising in undertaking street events to pull together the engagement package.

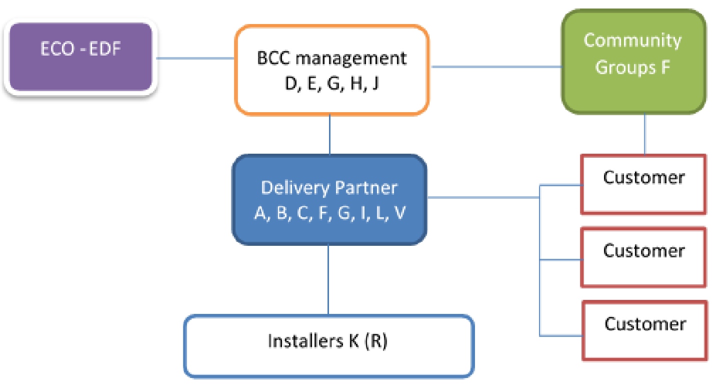
The intention was to have a street level engagement, then roll-out on a street by street basis to target possible economies of scale and reduce individual disruption (i.e. mimicking the economies of scale usually achievable in social housing schemes rather than owner occupier properties).

Work with the original delivery partner Climate Energy faced several challenges due to the following issues:

- Due to Government requirements, Climate Energy (only a negotiated tender partner at that time) was pushed to start delivery on a set of initial properties (competition winners), which was considered to be an unnecessarily rushed approach.
- The delivery partner was responsible for the delivery of 25% of Green Deals on a national scale and was therefore considered as unable to dedicate adequate time to the BCC scheme.
- Due to the size of the contractor, work was carried out across various areas in a seemingly unplanned manner. This resulted in a more pepper-pot approach and the resolution of issues over a long period, which in some cases was over a year.
- Subsequent delays also hindered the very detailed engagement plan that had been put in place by the CEP.

Due to delays, in some cases, contractors put scaffolding up and removed guttering, but only started work months after which caused significant problems for residents. In some cases, customers who had agreed to the installation were significantly delayed and would see other houses that had come in later to the scheme completed before due installers going into administration and a lack of rational approach from the delivery partner. In one case this delay was up to a year and a half. When promoting a scheme, these negative experiences are very unconstructive and undermine trust that has been built over long periods.

As a result of the difficulties experienced and the impact on the work, the scheme delivery model subsequently underwent a change in November 2015 (**Figure 20**) when Bristol City Council took the management of the delivery of the scheme in house following Climate Energy going into administration. In retrospect, a more achievable and sensible Government-defined delivery timeline would have been a key factor in project success and in avoiding problems that were experienced at later stages.



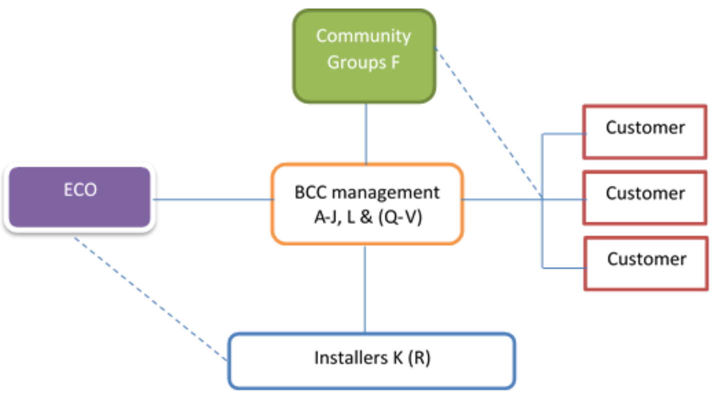


Figure 20 Original and revised delivery model. Source: BCC, 2016

While no whole-house or multiple measure retrofits were undertaken, in a limited number of installations, where multiple houses were retrofitted, a degree of sequencing was adopted. However, this was largely due to contractors requiring a certain volume per week to be profitable and to enable them to organise their sub-contractors accordingly. While the work has in general improved the look of many properties, there however has been some degradation to some properties such as loss of original features, odd detailing around original features to retain features and poor detailing, particularly for verge trims and vertical trims.

Quality Assurance and Inspection:

Pre installation EWI surveys were carried out as part of the Green Deal Assessment. During the Climate Energy phase of the project, the delivery partner wanted to appoint Green Deal Sales Advisors, however BCC were unhappy with the arrangement as they were not independent, were considered to be led by sales-based motivation and were largely not adequately trained to provide proper assessments or scope the required works. For other measures, the contactors undertook the technical surveys. This lack of experience led to a significant difference in costs.

BCC re-surveyed 150 properties and found inherent problems with the GDSA surveys. A more thorough survey process involving both the contractor and the clerk of works has now been put in place. This records key notes from the conversation with occupants and contractors and provides photographic evidence of the state of the property for records. Based on this new approach, a quote is only after this process is completed.

The clerk of works role was a BCC response to these challenges and was viewed as a particular success, they were engaged and attended the courses (funded by DECC) for designers and installers. They undertook an important independent QA role, challenging contractors to put in pilot holes to confirm the works had been installed as planned and redo it if not. However, there were not enough of these on the project. The CEP had asked for this team to be in place, but this did not take place till later on in the project.

The Cold Homes Energy Efficiency Survey Experts (CHEESE) project accessed through the CEPs aimed to provide homeowners with information on faults using low cost thermal imaging via surveys (**Figure 21**). These empowered customers to take action on faults via a post installation QA (CHEESE Bristol, 2017).

Figure 21: CHEESE Heat View: Web-based thermal imaging map of Bristol gathered between January and March 2015. Source: CHEESE Bristol, 2017

A key issue in terms of quality that was identified was that EWI is viewed as a low-skilled process and as simple energy efficiency measure (as defined through permitted development). However, it is in effect a construction project that should be approached like an extension to maintain quality and robustness of installations. There were issues were transient workforces, poor practices and issues with communication. There were also issues with payments (minimum wage issues as well as days not worked due to rain) which led to lack of retention. Communication barriers are a particular hindrance to effective communication of detailing approaches to workers who might be used to doing things in a different way. In addition, due to the nature of the city, finding workers to carry out works is very difficult. The Bristol Kite mark project aimed to provide information on trusted workers and installers.

Occupants and Community:

Prior to this project, EWI had been set up as an aspirational measure for Bristol residents through the various schemes and the city community energy groups that had predated GDC (dripping it into consumer consciousness to increase awareness) through exemplar homes in each area. Precursors to GDC that had benefitted from publicity and generated the market required for the GDC to be successful included 2.6M received by BCC under the Green Deal Go Early Scheme resulting in the Bristol Home Energy Upgrade Scheme (BHEU) with the Centre of sustainable Energy which mainly led to numerous boiler upgrades. The Green Deal Green Doors Scheme which involved occupants of 120 properties that had undergone upgrades, including deep retrofits and EWI ‘opening’ their doors over 5 years. The Local Energy Assessment Fund (LEAF) project provided funding for the Green Doors Scheme to provide EWI for a row of four terraces, the first time private owners had undertaken a joint upgrade, which was the subject of a widely attended event. These were all considered efforts by many actors on various scales that constituted a warming up of the market before any works had been planned.

In the areas targeted, many residents were therefore already environmentally conscious but had previously not had the sense of agency to action it. Therefore this scheme which was provided by a trusted local authority gave them the opportunity to do so. Given the nature of the housing stock in Bristol, where solid walls constitute 38% of properties (compared to 25% in other cities) and where buildings have unique, colourful and relatively uncomplicated facades, it was considered to be a desirable cosmetic measure that involved limited hassle as works were largely external. Importantly the housing stock also had considerable exposed areas within the solid wall stock that would have presented a key risk for IWI.

The community energy groups, crucially, acted as a catalyst for the scheme by coordinating applications for funds such as LEAF. They also facilitated events such as a ‘Meet an Installer’ event to generate interest. In response to the initially intended street-by-street approach, the leafleting approach aimed to showcase the benefits of this level of retrofit to occupants in regards to such aspects as minimising disruption. However, due to delays in funding, the CEP were not permitted to start communications till late in the process. As a result, Easton Energy had to hand out 5,000 leaflets to prospective customers within a very short time frame (‘playing catch up the whole time’). Whilst the conversion rates, particularly for door-knocking have seen approximately two-thirds conversion to assessments completed, the cost of door-knocking each home three times was high and after approaching all the houses initially identified, and the expanded number of streets, the decision was taken not to continue with a door-knocking approach for the longer-term citywide scheme unless there was an expectation that the offer would result in a very high conversion rate.

Table 16 Uptake of measures throughout the project

Customer journey stage	GDC	PRS	Total GDC/PRS

Homes marketed (door-knocked, in-coming or outgoing)	2276	975	3251
Assessments completed	1340	605	1945
Percentage uptake	59%	62%	60%
Installations completed	408	218	626
Percentage conversion	18%	22%	19%

Funding and Cost Effectiveness:

The budget for the BCC project was based on a number of funding schemes (**Table 17**). A financial model was developed by the Programme Manager to deliver the scheme within the boundaries of the Green Deal structure.

Table 17 Funding breakdown for the BCC GDC project. Source: BCC, 2016

Totals until 31st March 2016	Amount
DECC GDC/PRS Funding	£7,292,200.00
Council reserves	£127,342.45
ELENA Funding	£1,217,835.18
ECO Funding	£210,532.50

The aforementioned financial model used information provided by the Housing Stock Model on house size, construction and type (terraced, detached etc.), and the known existing EPC ratings for properties in the area. An approximated cost/m^2 install area for type using average industry installation costs was then calculated for a selection of common house types and sizes found in the target areas (e.g. 2 bed mid-terrace; 3 bed end terrace). The number of properties in a street that would be able to have EWI installed were approximated based on the visual appearance of the property – i.e. not stone or exposed brick finished to give the number of likely EWI installs and from this a percentage uptake was applied.

Under the Green Deal Communities installation programme a number of offers were set up with Wessex Home Improvement Loans, these can be summarised as follows:

- External Wall Insulation – two-thirds funding to a maximum value of £4,000.
- Any two other qualifying measures – two-thirds funding to a maximum value of £1,500.
- The two qualifying measures proved to be difficult to sign-up customers for installation so this was changed (with agreement of DECC) to any other qualifying measure – two-thirds funding to a maximum value of £1,500.

The further measures option provided a challenge in terms of uptake, as many customers in Bristol already had measures installed or did not want to spend an extra £1,500. As a result, the offer was redesigned as a further energy efficiency measure at two-thirds of the cost up to £4,000. A specific offer for the PRC was also set up where landlords were offered up to £15,000 for E-F-G rated properties (a specific criterion for PRS which was city-wide and not restricted to the three wards in the general scheme).

It should be noted that the pressure felt by BCC to deliver a set number as prescribed by DECC/BEIS was in turn put on the delivery partner whose main concern became costs, whereas the BCC's concern was the delivery of quality. This was viewed as the best value in the long term in terms of saving energy and carbon as well as not spending money on remedial works. For EWI specifically, the ranges of contractor costs and total install costs (what was paid by customers) are summarised in **Figure 22** and **Figure 23**.

EWI uptake through the installation offer appeared attractive to many homeowners, where it was set at a value that made it accessible for people to participate in the scheme. A total of 677 measures have been installed as of 31/03/16 (GDC & PRS installations), on 626 properties. Where the total incentive value allocated against the installs to date is £1,600,000 with an average value of grant issued of approximately £2,600 an the average customer contribution was £1,300.

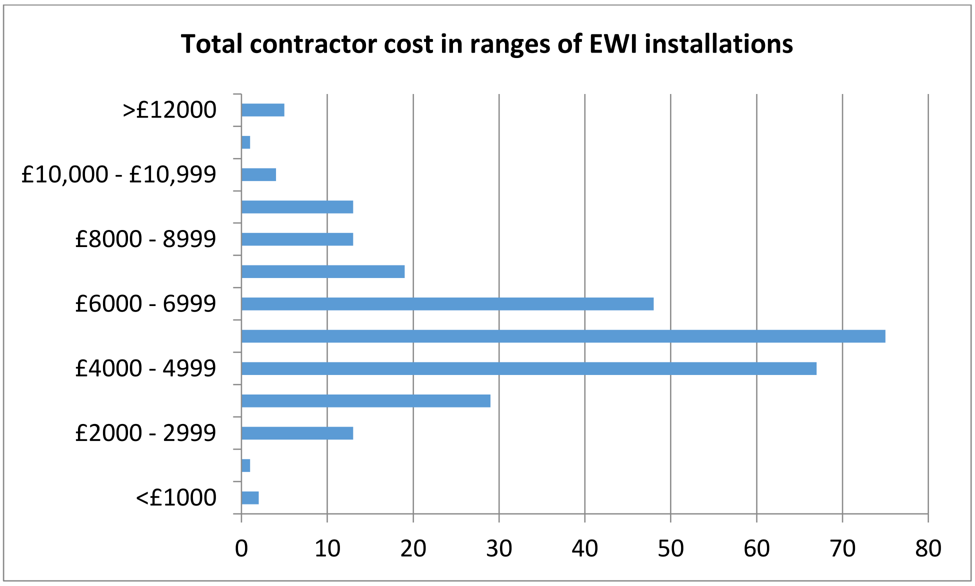


Figure 22 Contractor costs (total number of properties) in ranges of £1000, EWI only (290 Properties).

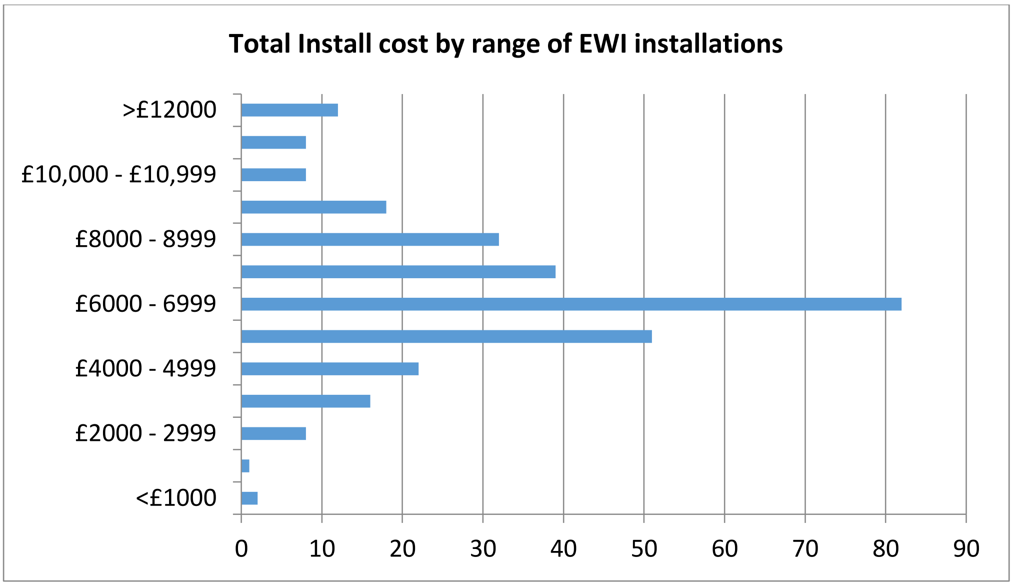


Figure 23 Total amount payable by customers by ranges of £1000, EWI only (299 Properties).

In terms of lifetime bill savings, for installations where ECO was claimed through the Warm Up Bristol scheme, it was approximated that £353,140 of savings were achieved for customers. For the GDC as a whole, no customer surveys were undertaken to verify these savings. It should be noted that for some customers savings were not achieved due to the take-back factor. The total calculated carbon savings for all installations included in this scheme was calculated at 6191 TCO_2.

Table 18 Cost effectiveness indicators of the BCC GDC project. Source: BCC, 2016

Indicator			
CO_2 savings	Average annual CO_2 savings per household (tonnes)	Total annual CO_2 savings (tonnes)	Total lifetime CO_2 savings (tonnes)
	9.9	6191	N/A
Energy bill savings	Average annual financial savings per household	Total annual financial savings	Total lifetime financial savings
	£567	£353,140	£N/A

Table 19 illustrates the specific costing parameters of EWI for the BCC project. This includes contractor costs, (average, min and max); total cost to customer (average, min and max); average costs per sqm. install (average, min and max); number of days required to install EWI (average, min and max). The number of properties in each calculation is shown in the first column.

Table 19 EWI Cost parameters

Total properties	Measurement	Amount £
293	Average contractor cost	£5,793.00
	Minimum cost contractor	£480.00
	Maximum cost contractor	£23,957.00
300	Average Total cost	£6,939.00
	Minimum cost per install	£480.00
	Maximum cost per install	£27,690.00
236	Average cost p/m2 installed	£111.54
	Minimum cost p/m2	£28.76
	Maximum cost p/m2	£287.45
91	Average number of days for installation	43.12
	Minimum number of days for install	19.00
	Maximum number of days for install	161.00

In general, there has been an improvement in the homes that participated in the scheme. This is mainly anecdotal and mostly focused on appearance. Improvements to performance, cost and bills are difficult to specifically quantify as no monitoring was allowed through funding on the scheme and the Council was unable to fund this itself.

The main elements impacting project costs include:

- **Inadequate planning periods:** The push for quick delivery led to a short planning phase that did not allow for all aspects to be carefully considered. Therefore, shorter deadlines and arbitrary timelines dictated by financial years rather than more practical constraints (holidays, seasonal changes…etc.) should be avoided for these schemes going forward to allow for proper planning and appointment of appropriate delivery partner.
- **Fragmented delivery:** The street-by-street approach was initially adopted to help with cost efficiencies and the management process of the works for the contractors. However, the Delivery Partner did not view it from that perspective, instead adopting a responsive approach based on customer responses. As a result of varying timelines in customer decision making, this led to a much more fragmented delivery model.
- **Delivery partner set up:** The delivery partner was responsible for the delivery of 25% of Green Deals on a national scale and therefore might have not been able to dedicate adequate time to the BCC scheme. An office had to be set up for them in Bristol therefore increasing their costs significantly.
- **EWI remedial works:** Remedial works are currently being carried out on projects where contractors went into administration and for works that were done improperly. These often are projects where structural enabling works were not carried out in the first place. These works

should be undertaken as standard and should be supported through funding such as dedicated schemes that are already in place in Scotland.

The main opportunities to achieve cost reduction (provided that an adequate number of properties are targeted) include aspects such as:

- **Informed and managed decision-making:** A stricter time-limited offer to customers would ensure that the level of occupant sign-up required to enable a more mass approach to deployment would be supported.
- **Wider engagement with industry:** The creation of a sense of agency not only for customers but also for the industry is key for wider scale implementation. The industry was viewed as not being fully engaged with EWI, therefore Best-Practice should be communicated with them and they should be incentivised to ensure quality delivery. In European cities, the approach involves engaging with installers at an early stage by first familiarising them with the building stock, its characteristics and challenges. Following this, the technologies are also communicated to them and they are incentivised to be part of the schemes. A delivery plan is then developed with the local industry and only after that do schemes commence. A key concern is that lessons learnt through training may not be used/realised on-site.
- **National delivery:** Retrofit needs to be viewed as a national infrastructure project, well thought through to delivery national benefits. The investment period should be reviewed to an extended period. (30 years plus) as in Europe.

3.5 Greater Manchester Combined Authority GDC Scheme

The key lessons from this project are

Best-Practice and quality

- In recruiting homeowners and others to the programme, the trusted nature of the local authorities played an important role, particularly given the lack of currency of the commercial partners in this sector.
- The private housing sector presented particular challenges to the commercial partners, who were more accustomed to operating in a social housing environment, and there is evidence that this caused delays in the delivery of the programme.
- The work undertaken was captured as part of a 'Retrofit Pattern Book' that allowed the upload and sharing of their Best-Practice details.

Costs, impact and opportunities for economies of scale:

- Where a street-by-street approach was achieved, this evidenced some benefits. To the commercial partners these included economies of scale relating to scaffolding, deliveries, storage and staffing.
- The typical cost of works on a mid-terrace building was around £6,000-£8,000, while that of an end terrace was around £12,000.
- Anecdotal feedback from residents, suggested that works led to an increase in property value in the region of £10,000-£12,000 (where the national average increase was believed to be £16,000).

i. Overview

In 2014 GM received £6.1 M of funding from DECC to deliver Green Deal Communities under a scheme dubbed as 'Little Bill'. This resulted in the upgrade of more than a target of 1,200 properties in the Greater Manchester area, with works carried on a number of building typologies, but predominantly on terraced houses. The program targeted households with mixed-tenure (including owner occupants, private rentals, social housing and landlords). The construction approach was a street-by-street approach, allowing everyone who was eligible to take part in the scheme. The initial aims of the GMCA GDC schemes were (Trafford Council, 2014):

- Support 1,000 jobs across the supply chain, whilst opening up opportunities for new GM apprenticeship and training activities;
- Assist 5,000 households make their homes warmer, with at least 2,000 of these households being supported out of fuel poverty; and
- Save approximately £3m in NHS costs in addressing fuel poverty.

The programme has seen the installation of EWI in a large number of households in GM with relatively little outlay from residents. The programme met its targets for signups and installations and is possibly the only UK participating area to have achieved this.

ii. Analysis and Findings

Retrofit Strategy:

The scheme aimed to commence with a number of show-house demonstrator cases across the region. These aimed to kick-start the program. However, due to the tight time-frame, the show-case homes could not have been completed by the time the program was meant to kick-off. Overall, the initial 2,000 sign-ups, were later reduced to 1,205 installations (by 2016, 1302 households in total receiving measures).

Initially, a whole-house approach (refurbishing whole houses rather than focusing on individual features within them) was developed, aiming to achieve a combination of aesthetic and environmental goals. Very quickly, however, project aims were revised to enable achieving as many as possible house sign-ups and set number of installations to meet the DECC/BEIS target. While EPS was used as the main EWI system (with some mineral fibre), a diverse range of EWI systems and details were available through the scheme. The selection process depended on homeowner preferences, contractor preferences, architect advice, system manufacturers and local authorities.

Before plans for GDC were finalised, a framework for retrofit in GM was created with a view to simplifying the process for local authorities to carry out household improvements and to maximise the potential to apply Green Deal and ECO funding across the boroughs. In terms of delivering outputs, while BEIS was mainly interested in the number of households participating in the program, internally - the Greater Manchester team was also interested in achieving other goals - creating jobs locally, regeneration of local communities etc. Calculations of carbon reduction were undertaken.

Installation and Deployment:

The properties were of mixed tenure (owner occupants, private rentals social housing and landlords), and construction was carried out on a street-by-street and whole area-based approach in most cases. Before the program started, Greater Manchester had just completed a procurement process (as part of the GMCA Green Deal), where it had developed a co-framework with 3 partners – all large national contractors. This meant that prior to the launch of the GDC program, GMCA had already had 3 construction partners in place.

In practice each partner was allocated a number of properties, managed their own sub-contractors, and reported back to GMCA. Changes in national policy (e.g. Green Deal Home Improvement Fund) meant that the programme had to revise its offer so not to conflict with national offers that were also available at the same time.

While procurement processes often focus on supplying generic insulation systems suitable for most buildings, in this project, as per Green Deal guidelines and other technical documentation which recommends avoiding generic EWI systems, EWI solutions tailored for specific buildings were designed. The main driver for using specific insulation system was based on its visual impact (i.e. to improve the streetscape), therefore the use of generic EWI solutions were viewed to have potential risks, were issues such as fabric failure, water penetration, condensation could actually adversely impact the visual appearance of buildings and streetscape. For this project it was assumed that there is a 15-30% performance difference if thermal bridges are treated and a continuous insulate envelope is kept, rather than insulating individual elements and leaving gaps in between them.

Time-scales in most funding schemes were considered to be too short, and consequently do not allow proper strategic planning of the different works (design, supply-chain, construction). One of the reasons for the success of the program was due to the fact that the 3 enterprises (contractors) involved applied fairly flexible and collaborative practices to help each other through applying their expertise. This approach was viewed as being so effective that one contractor was subsequently selected by another framework partner to specifically to solve a problem. It is noted, though, that whenever needed , local suppliers were commissioned for the works (e.g. for EWI installs, for supplying scaffolds).

The work undertaken for the project was captured as part of a ‘Retrofit Pattern Book’ a website-based platform (**Figure 24**) that allows designers and manufacturers to upload and share example of their Best-Practice details with others (GMCA et al., 2017).

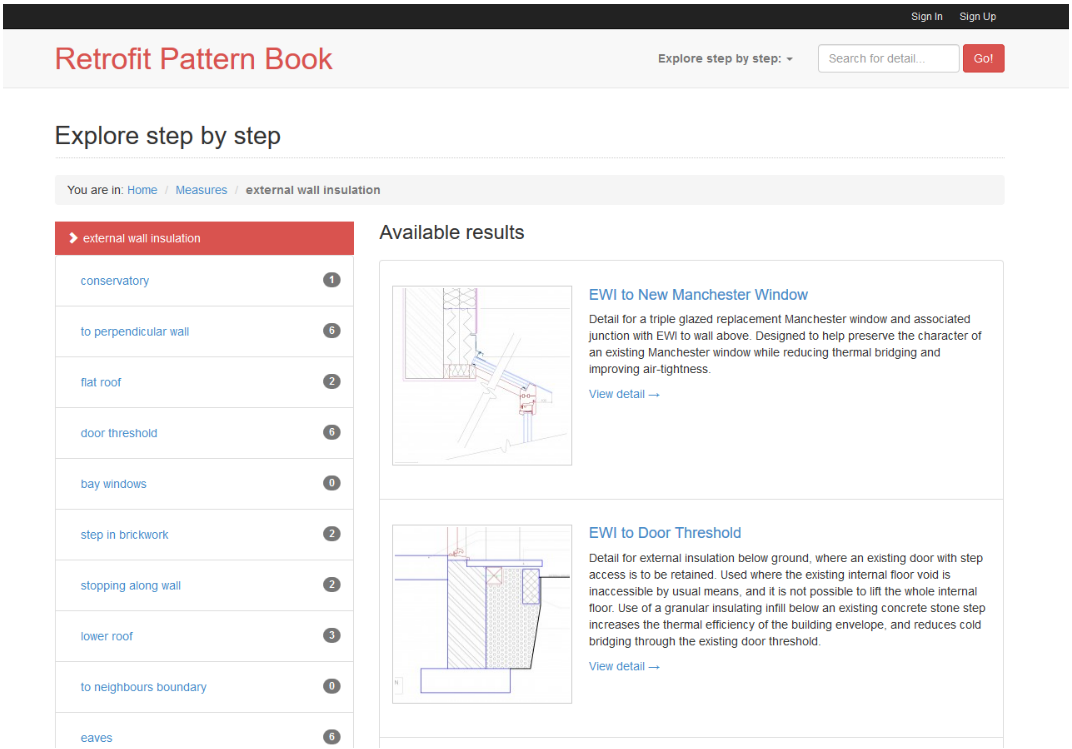


Figure 24 EWI detailing section on the Retrofit Pattern Book portal. Source: GMCA et al., 2017

Quality Assurance and Inspection:

Completing a series of buildings in a whole area-based approach at the same location at the same time led to a site management and QA processes that were significantly easier to implement, simplifying aspects such as coordination between different professionals, securing access to properties and sign-off procedures.

While some projects tied QA checks to sign-off, with site inspections undertaken regularly (by local authorities), the main QA strategy largely relied on in-house QA checks. These procedures were normally carried within each of the businesses involved, where each party in the supply chain is responsible for their own QA (manufacturer, supplier, installer etc.

Occupants and Community:

The program had mixed tenure households. Most participants were of fuel-poor background and from low-income communities. The value proposition for households to join the program was the improvement of their overall comfort in the long run, where comfort was views as a more pleasant environment, improved aesthetics, and ability to heat spaces while spending less money and health benefits (**see section 2.5**)such as decreasing the frequency of asthma attacks. Breaking down the term ‘comfort’, the main incentive for most households for joining the program was improving the looks of their homes. The initial state of some properties (especially properties that were meant to be used for 20 years e.g. post war tin houses) was extremely degraded, and residents (mainly owner occupiers) wished to uplift their living spaces. Saving money for running the building was mentioned as a secondary incentive. Prior to the program, some households could only heat part of their houses, and they wished to improve their thermal comfort within the property. Environmental awareness incentives were almost negligible.

The program used various means of communication with residents. These included door knocking, letters, phone calls, local community events etc. In most cases, social media campaigns was initially used but then realised to not be as effective as direct engagement. A close relationship and cooperation with local authorities was mentioned as an important means to gain resident trust, as council delegates were perceived to be more reliable. Another approach using a ‘dichotomy of trust’, where residents were approached by as many parties as possible, including local authorities , was perceived as the most successful approach.

Teams noted that the program was very persistent – team members were visiting residents repeatedly, providing useful information and a 'can-do attitude', until residents were confident enough to join the program. Communication with the residents was very much about understanding the community and its needs, as well as cooperation with the council. Residents were apparently satisfied with the means of communication and project outcomes, as in some cases communication means were reversed – family members of residents who joined and completed the program approached the project teams, asking to join subsequent schemes and new projects. The whole area-based approach made the communication, design and construction process, as well as the site-management, much more efficient (Sherriff and Swan, 2016).

In most cases, no follow-ups, monitoring or 'lessons learned' sessions were conducted after the hand-over. In some projects, instructions were given to residents at different phases of the program: council officers were responsible for completion visits, sign-offs and handing over guaranties. When new vents or extractors were installed, some fitters had instructed residents on site on how best to adapt some of their habits (cooking for example) to best ventilate their houses. In other cases, printed instructions and guidelines were produced, explaining what is the best way to use thermostat, ventilation etc., once construction works are done.

To secure the future proofing of the installation, as part of the EWI design and installation, residents were a asked whether they might, in the future, wish to install various external fittings (such as satellite dish, for example). This was then taken into account. Where this was not part of the design process - an agent visited the house with the tenant, as part of the hand-over procedure, and explain how they should use their houses. These instructions were especially important in cases where owners would like, in the future, to further remodel their properties or incorporate external fitting that might affect the performance of the newly-refurbished houses.

Funding and Cost Effectiveness:

The project was funded by GDC (75%) and the remaining 25% (over £3M) came from customer contributions, local council contributions and Energy Company Obligation funds. Some local authorities had interest free loans available to assist residents with their contribution payments. In some cases, local councils contributed some funding for landscaping and general neighbourhood uplifting. Funding was a main driver in this project, but also a constraint in some cases. Some households were granted a full fund for construction works to be carried out if they were deemed as fuel poor by the local authority, and in these instances the local authority paid the customer contribution. This was, however, not viewed as a sustainable approach for a 24 million nation-wide scheme.

Interest-free loans made available to residents e.g. via credit unions, Care and Repair (all Council backed loan mechanisms) were highly attractive to residents, in some instances (e.g. in Wigan) the loan mechanism meant the repayment only takes place when the house is sold. The programme's convenient loan conditions were considered very appealing, and perceived as unique opportunity to upgrade living standards, particularly when national policy altered and GD Finance was no longer available.

In one case, funding that was initially offered (i.e. through national GD Finance) could not be secured. The large number of occupants who had applied for the program were consequently asked to meet the shortage in funds (around £2,500), and this was done luckily through a Council loan mechanism that was available, however not all Councils in GM have this function available. The typical cost of works on a mid-terrace building was around £6,000-£8,000, while that of an end terrace was around £12,000. It should be noted that that costs varied significantly depending on the period and technique the house was built at and the design of appropriate construction details that fit the building type. Anecdotal feedback from residents, suggested that works led to an increase in property value in the region of £10,000-£12,000 (where the national average increase was believed to be £16,000). Performance improvement (in terms of decreases to energy bills) were believed to be around 15%-30%.

Table 20 Cost effectiveness indicators of the GMCA GDC project. Source: Swan & Sherriff, 2015)

Indicator			
CO_2 savings	Average annual CO_2 savings per household (tonnes)	Total annual CO_2 savings (tonnes)	Total lifetime CO_2 savings (tonnes)
	9.09	12,000	N/A
Energy bill savings	Average annual financial savings per household	Total annual financial savings	Total lifetime financial savings
	£350	£462,000	£N/A

Project participants noted that many ‘easy-EWI’ homes have already been improved, and that much of the current un-refurbished housing stock consists of properties that are harder to insulate and require more significant EWI measures, e.g. damp proof course, remedial works. This means that the cost of insulating the remaining stock may by nature be, therefore, more expensive.

The main elements impacting project costs include:

- **Up-front design and detailing:** These aspects as well as proper and reliable survey are essential to provide cost certainty. It seems that at the moment, the quality if surveyors and assessors varies widely. This can lead to extreme variations in actual costs.

- **Tailored/ bespoke detailing:** Although costs that can vary significantly depending on the building age and construction technique, the design of appropriate construction details that fit the building type such as window reveals, or EWI products around ducts is an expensive process that has a high cost impact. For example, Victorian window seals are different than modern ones. Each requires unique detailing to prevent thermal bridges and rain water from seeping in.

- **Early engagement with planning:** Having planning officers on board at the start of the project made a significant difference and speeded-up some installations, as planning officers felt part of the program and approve applications quite easily.

- **Increased QA procedures:** Added inspection increases the cost of delivery, yet it is assumed to be still cheaper than works being done poorly and the re-done later on. Sub-contractors might give quality assurance a minor attention, which increases the risk of poor performance even more.

Opportunities for cost reduction due to the economies of scale were considered to be limited. While the general misconception is that EWI is a new feature, and that its cost will go down as it is used more widely, it has in fact been commonly used in the UK for the last 40 years, and in reality the cost of EWI materials will go up while construction budgets often go down.

The main opportunities to achieve cost reduction (provided that an adequate number of properties are targeted) include aspects such as:

- **Up-front funding for design and procurement of goods:** This not only simplifies the whole process, but supports faster implementation. This however should be supported by increased funding and a greater commitment from the central government.

- **Bulk purchasing:** Cost savings can be made with large product orders if with numerous households are targeted (a whole-area approach) this can be further reduced with efficiencies in scaffolding and site management.

3.6 Nottingham City Council Greener HousiNG

The key lessons from this project are:

Best-Practice and quality

- Installation delays were minimized by careful stock management in a local warehouse.
- Site works were minimised by preparing individual house packs with products cut to fit before delivery.
- Phased implementation allowed continuous worker employment and maximum value from training, which was delivered locally.
- Custom products were needed to satisfy planner requirements on particular details.

Costs, impact and opportunities for economies of scale

- Costs were de-risked by agreeing the design in advance of setting the price.
- Maintenance was included in the overall costing and designs were chosen to minimise maintenance.
- Indicative cost from one area, benefitting from considerable economies of scale, was estimated at around £6,500 per house, including enabling works.
- Private owners were offered exactly the same measures as tenants. They would have preferred customisation but this would have increased costs.
- A fixed price offer based on the property's archetype was determined for private owners (on average £2300). This allowed installers to be able to quote price 'on the doorstep' and interest free loans were made available.

i. Overview

Nottingham City Council received a government grant of approximately £5.5M under the Green Deal Communities scheme. As a result of this funding, the council undertook a large-scale retrofit program of its housing stock (Greener HousiNG). While almost all properties targeted belonged to the social housing sector rented out by the council, a number of 'infill' owner-occupied homes were also included. The funding for these was secured from a combination of ECO/GDC and enabled residents in these properties to be offered the same funding deal as what was available for social housing.

The project involved stakeholders such as project manager Nottingham City Homes (NCH), contractor Volkerlaser, Nottingham Energy Partnership and Sustainable Building Services (SBS). NCH engaged SBS in May 2015 for a project to install solid wall insulation on mainly council homes, commencing with a single estate, Lenton Abbey where installations began in November 2015. Work continued in several other areas over phases including Windmill Lane, Aspley, concrete houses in the Clifton area (Johnston, 2014) and current works are being undertaken in a block of flats in Newark Crescent. In total, more than 1100 homes covering over 20 archetypes have received solid wall insulation as part of the project.

ii- Analysis and Findings

Retrofit Strategy:

NCH's biggest environmental impact is the carbon emissions of its homes, and since NCH aims to be low or zero carbon by 2050. While 57% of the NCH domestic stock has insulated cavity walls, the remaining properties (around 4,000 homes) were classed as Hard to Treat. These were highlighted as the worst performing homes, in which tenants are most likely to be in fuel poverty. The improvement of these homes, which requires the installation of solid wall insulation, not only delivers the carbon savings targeted by the NCH, but has the potential to deliver the biggest impact for NCH customers. For the residents, energy savings (and less likelihood of rent arrears) and thermal comfort were highlighted as very significant drivers. To realise this, the strategy aimed to achieve a U-value of 0.3 W/m2K (average value) over the façade for the properties targeted.

NCH also aimed to make these homes ready for low temperature heating systems (heat pumps or district heat) in the future. In addition, area improvement was also a key aim, as some of the areas were run down and did not have a good reputation. One of the estates was prone to damp and mould and this was expected to improve as a result of the project (NCH, 2016b).

Therefore, the main goal of the strategy was to roll-out energy efficient refurbishment across this stock, to bring it up to a standard fit for today while avoiding the creation of future problems. This was especially relevant given prior experience where previous projects had installed cavity wall insulation that was not good quality and subsequently had to be removed. Due to a number of issues that have occurred in roll-out (e.g. constraints of limited budgets) a revised future strategy has included a requirement for ensuring that that future, not only current, standards are met. For this reason the proposed change in direction will aim to deliver much better whole house retrofit solutions, which achieve as close as possible to zero carbon straight away (NCH, 2016b).

Installation and Deployment:

Phase 2 of the project (Clifton South), was split up into zones to enable delivery on a street by street basis (Johnston, 2014). SBS contracted PermaRock for product supply and design work. PermaRock supplied design drawings for how their products were to be installed and how specific details should be handled, for example plinths, fence posts, gable ends. The bulk of the insulation was 90mm of expanded polystyrene (EPS). However, the insulation would be thinner over a brick plinth, and thicker above it to achieve the overall target U-value. The EPS was fixed with both mechanical fixings and adhesive. Since the walls were often not sufficiently flat, mechanical fixings alone would not have been adequate.

The render was designed to be maintenance free. The insulation was covered with a polymer-modified cementitious base coat for resilience, then a glass-fibre reinforcing mesh, painted primer and self-cleaning silicone Nano quartz top coat. Bespoke over-sills were designed with a grey colour to meet planning requirements, using polyester-powder coat aluminium. Some homes had tile cladding on upper floors – these were left untouched (though they may be insulated internally). As every house was in practice different (even when they appeared to be very similar), some products were made to measure. Insulation boards were also pre-cut to size, to reduce on-site works. The suppliers put together a 'house pack' for each home with the exact requirements for that case. SBS acquired a warehouse local to the area to keep stock nearby and PermaRock monitored the stocks weekly.

The process for each home was generally completed within 7 weeks, from initial survey to completion. The on-site work on average took more than 4 weeks, which could be quite disruptive and was at times delayed due to the weather. (NCH, 2016a). Enabling works including the necessary and boiler replacements were put in place before insulation. This included:

- Boiler replacements were needed where the existing boiler flues could not be extended, which meant replacing 40 out of 104 boilers in the most recent stage of work. These had to be replaced with modern boilers, which brought additional energy and carbon savings.
- Mechanical extract ventilation was fitted to wet rooms if it was lacking.
- Windows without trickle vents were also upgraded to ensure adequate ventilation.
- Overflow pipes and ventilation bricks were adjusted allow for the thickness of the EWI.
- Renovation of electric wiring was undertaken when necessary

One key factor in this project was teamwork – all stakeholders including clients, contractors and residents were involved from start to finish. Early contact between contractors and client helped to build trust. Resources were committed from both sides even before contracts were signed. Detailed design decisions were made before the price was set, so it was not necessary to make compromises later to fit the budget. The designers worked closely with planners to agree detailed design issues. This resulted in some compromises – for example porches on some homes were left untouched. In other areas, brick slip details were incorporated for example on door and window architraves, to maintain continuity of form.

Planners in Nottingham worked with NCH on projects being delivered in estates such as Lenton Abbey, and have been generally positive about the results. However they have stated that the solution used would not be satisfactory for all Nottingham red brick estates (NCH, 2016a). Due to the visibility of solid wall insulation, communities which have not yet received it have expressed their keenness to participate in the programme (NCH, 2016).

Quality Assurance and Inspection:

PermaRock provided bespoke training for installation contractors and subcontractors to cover use of their products and the detailing agreed for the houses in this contract. 400 individuals attended, though not all completed the course (and some unsuitable subcontractors were sifted out).This was provided at an office procured by SBS no more than 5 minutes from the first site and next door to the warehouse.

There were full time PermaRock technicians on site at all times to advise and oversee installation work. All completed work was signed off by PermaRock and SBS. Where E.ON was providing grant funding through the Energy Company Obligation, E.ON inspectors were also part of the inspection regime. Despite these inspections some issues occurred:

- Window reveals were at times left uninsulated due to a lack of space. This occurred when windows opened outwards, with a narrow gap to the reveal, and could not be replaced with more suitable designs.
- Gas and electricity meters were left in-situ as it was too expensive to move them.
- Insulation was only applied to the DPC level with nothing below ground. It should be noted that insulation guarantees only apply to applications above the DPC level. Assurance, and hence grant funding, cannot be offered for work below the DPC.
- It was not possible to extend the eaves of roofs because of financial constraints, so verge trims were used in some cases.
- Planning considerations and technical limitations also meant that porches could not be insulated.

NCH is currently engaged in further retrofit work through Energiesprong. For this project, requirements will include performance targets in terms of actual energy savings, and the contractors will be given more freedom on how to achieve them to give more scope for innovation. The approach also requires performance to be monitored over 30 years. The monitoring program needs to run with minimal administration with regular reports generated automatically highlighting issues that need attention.

Occupants and Community:

Residents (including family members for vulnerable residents), were engaged through a strategy that aimed to allow them to be part of the consultation process from start to finish. This included an invitation to visit a show home, which was staffed with a full-time liaison officer from SBS and sending out an information booklet. The booklet prepared jointly by NCH and SBS described what would be done, how tenants would be affected during the works, and what they needed to do to prepare for it. Private home owners in the Lenton Abbey area were offered the opportunity to take part in the process. Those that did so, were more engaged than tenants.

When each home was completed the residents were visited by a liaison officer and provided with further information booklets. These included energy saving tips as well as information about maintenance, cleaning, how to attach fixings to the wall and how to seal around any new penetrations for pipes etc. On completion, some of the residents were invited to customer journey events – typically 10 residents at a time – to give feedback. Some attended to make complaints but others were keen to help as they were pleased with the improvements.

Funding and Cost Effectiveness:

The bulk of the funding used for the project was sourced internally from the City Council Housing Revenue Account. ECO provided some of the funding (10-15% initially, falling to 8%), and motivated by improving tenant welfare, regeneration benefits, and reducing carbon emissions (as part of NCH's Sustainable Homes Strategy). The Green Deal Communities fund was used to help fund private home owners taking part.

NCH plans 30 years ahead so takes a long term view, therefore value was viewed as being more important than price in regards to the costs of EWI. As such, choosing contractors purely on price was not viewed as a sound approach. PermaRock and Sustainable Building Services offered reliability and good quality for a realistic price. Maintenance and enabling costs were included in the cost evaluation, where the enabling works constituted a significant part.

A fixed price offer (**Figure 25**) for EWI based on the property's archetype was determined for private owners (on average £2300). This allowed installers to be able to quote price 'on the doorstep' (Johnston, 2014). The balance of the cost was met by Green Deal Communities funding. Interest free loans were made available. It should be noted while some private owners highlighted that they would have preferred to have distinguishing features installed, to maintain the 'look' of the area both tenants and owner-occupiers were all offered exactly the same design.

Figure 25: What's my contribution: archetype-based price ... NCH, 2015

Limited cost data was available for this project. An NCH estimate of average EWI costs in its stock is around £6,000-£8,000 per property, leading to a saving of around £240 per year (NCH, 2016a). In general, in regards to the fixed prices given to private owners, the balance of the cost was met by Green Deal Communities funding and interest free loans were made available. As an indication of actual costs, for the Windmill Lane homes costs were around £6,500 per house, including enabling works. This benefits from considerable economies of scale.

A future modelling exercise for EWI investment in Nottingham was undertaken as part of scenario-based study to inform the development of an action plan for sustainable energy development in Nottingham. The work assessed the economic viability of EWI in the city. The implementation of this measure under a LL-Growth scenario representing the maximum level of local engagement modelled during the development of future energy scenarios for the city of Nottingham was undertaken (Long and Roberts, 2017). Results were slightly lower than would be expected under the Reference (current) scenario. Economic viability for the limited degree of implementation under LL-Growth is shown in **Table 21.**

Table 21 Economic viability for the installation of solid wall insulation in suitable properties in Nottingham. Source: Long and Roberts, 2017

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	7,873	13,122	13,972	4.22	215	64.95

The main elements impacting project costs include:

- **Availability of skills:** Using less experienced workers increases management costs. While local workers were used (this was one of the KPIs for the project), a high proportion of the trained installers were from the EU. Post-Brexit there could be problems in recruiting the skilled workers required for this type of work.
- **Price uncertainty:** PermaRock manufactures in the UK but some products and most raw materials are imported, for example from Germany. It is likely that costs will increase in future as a result of the weaker pound sterling and the subsequent higher costs of imported materials.
- **Design iterations:** Getting the design right is a critical part of the process, where all parties, including the client, planners and the tenants have to agree. In one development 60 design iterations were undertaken before all parties were satisfied. This extended implementation time and impacted costs.

The main opportunities to achieve cost reduction (provided that an adequate number of properties are targeted) include aspects such as:

- **Continuity of work:** This was a key factor in bringing costs down. The work was done in phases, with each new development overlapping with the previous one. This meant that personnel and infrastructure could be transferred straight from one job to another, thus minimising waste of resources. At the peak, with three developments overlapping, there were 100-120 workers employed.
- **Scaling up delivery:** The targeting of specific archetypes and developing designs with more off-site manufacturing, less labour intensive delivery. This could take long-term investment (approximated to be up to 5 years) before delivery commences.
- **Stockholding and management**: Stock management was key to avoid delays and wasted labour time. SBS acquired a warehouse local to the area to keep stock nearby and PermaRock monitored the stocks weekly. Preparing and supplying a ‘home pack’ with all materials needed for each house to be renovated, cut to the correct dimensions, which accelerated site work and reduced the risk of problems and errors from on-site cutting.
- **Design for cost de-risking:** Costs were de-risked by agreeing the design in advance of setting the price.
  In addition, private owners were offered exactly the same measures as tenants. They would have preferred customisation but this would have increased costs.

4 Findings and Conclusions

The following section combines the overarching lessons learned, and aims to answer the key research questions defined for this work. In interpreting these findings, it is important to consider the boundaries of the investigation which are determined by both the context and characteristics of the projects discussed as well as by the nature of the hindsight review meetings themselves.

1-How does the cost of SWI retrofits compare across different projects? How are these costs associated with retrofit quality?

Based on available information, the cost variation of measures, as found in existing literature on previous projects as well as in the case studies analysed, is considerable. The cost ranges of installations, summarised in **Table 22,** varied between approximately £3900 (Bristol) to over £12,000 (GMCA) for a single dwelling. Customer contributions were similarly variable and ranged between £750 to £10,000. Average financial savings per household achieved (when information was available) ranged between £222 to £567, where no clear association between the costs incurred and extent of savings could be observed.

Table 22 Summary cost information

Project	Cost summary	Owner contribution	Notes
Slough Borough Council	Average cost of measures: £11,000 (house) £133,000-£160,000 (block)	£10,000 cap	GDHIF was sought during the first phase for the privately owned homes, when this was no longer available, works were subsequently funded through the council
Haringey Smart Homes	Average capital cost of measures £4,252	25% of cost contribution - £750-£1,500	Financial offering Op1: £6,000 grant + 25% contribution included EWI in addition to other measure. Option 2: £3,000 + 25% contribution including softer measures
Bristol City Council Green Doors / GDC	Average cost of measure £ 3,900	Average contribution £1,300	Financial offering: EWI – two-thirds funding £4000 max Any two other measures – two-thirds funding £1500 max (changed with agreement of DECC) to any other measure – two-thirds funding to £1500 max). Landlords offered up to £15k for E-F-G rated homes
Greater Manchester Combined Authority Little Bill/ GDC	Average cost of measures £6000-£8,000 (mid terrace) £12,000 (end terrace)	25% of cost - £1,500-£3,000	Contribution paid with up to 25% interest-rate loan pre-paid with the property
Nottingham City Greener HousiNG	Average £6,000—£8,000 per property	Fixed price average £2,300/ owner	A fixed price offer based on archetype for private owners with interest free loan

Despite the relatively high costs involved, project participants, across all case studies (who, it should be noted, were largely stakeholders rather than residents themselves) viewed that cost in itself was not the main barrier to EWI deployment. When cost is viewed in the context of a more complex customer value proposition interpreted by the customer, the perceived value of EWI (e.g. 'better, greener, warmer' homes) was considered to outweigh any potential cost issues, especially in light of the total value of the work that was carried out and the interest-free loans available to cover customer contributions. To illustrate this, it was highlighted that in mixed-tenure properties leaseholders who were at first likely to oppose works due to the costs involved, tended to be more engaged in the retrofit process (than tenants) when they were convinced of its benefits.

Maintaining quality was a main aim across all projects, with poor quality installation actually leading to increased costs for remedial works in the Bristol GDC project. To maintain quality, project participants all viewed that a more holistic and sustainable approach to evaluating cost efficiency as a metric needs to be considered. Here, a best value approach (which should not be confused with the 'cheapest option') that considers cost using a more long term lifecycle approach should be adopted instead of the current cost and value for money approaches used by the government. This factors in not only installation costs and the proportion of grant funding available, but also maintenance costs (over, for example for the Slough project, the assumed EWI installation 36-year lifespan) as well as the long term benefits of the project to occupants and homeowners.

Within this context, Best-Practice is a key determinant of cost efficiency. To illustrate this for case study projects analysed in this report, **Table 23** summarises each project's Best-Practice lessons, aims to determine the cost impact of each (in terms of relative magnitude of each) and highlight potential areas of cost efficiency. Overall feedback suggests that the areas where significant cost savings can be made when applying economies of scale include fixed costs such as administration, process-based costs such as warehousing and stock-holding and enabling works such a scaffolding. For example, in the Greater Manchester Combined Authority GDC Scheme and the Slough Borough Council project, the representatives of national-scale construction companies noted that the main areas of cost-savings include efficient use of scaffolding, while material costs are relatively fixed.

In a grant funding – based environment the processes which hampered cost efficient delivery were largely due to the inconsistent short-term nature of the funding schemes themselves. These funding models were largely considered to not support the adequate planning periods needed to achieve the high quality installations (such as the Nottingham case study), enable the more widespread uptake and maintain the supply chains required to achieve cost efficiency of the measure.

The main method to achieving significant economies of scale is by having a large cohort which could be taken as a package to procurement. This is probably more viable in situations where a large group of properties was under the same owner ship and co-located to some extent. When targeting a private sector market, this clustering maybe achieved via a phased approach and increased marketing. In addition, EWI interventions should, ideally, take place alongside other performance-improvement construction works (such as window and boiler replacement). This integration between the installation of different measures can result not only in a healthier and better building, but also in a potentially cheaper outcome overall, compared to a case in which each improvement is installed separately.

Table 23 Project assessment matrix: Key areas of Best-Practice and their relative cost impacts

Project	Technical		Supply Chain & Deployment		Occupant & Community		Funding	
Slough Borough Council	Single EWI measure Staged QA Future-proofing EWI Structural de-risking	*** ** *** ***	Integrated, single EWI contractor Estate-based installation Scaffolding co-ordination Acquisition of a local warehouse	*** *** *** ***	Community-wide consultation	*	Long term ‘Best value’ costing approach	***
Haringey Smart Homes	Multi-measured approach Mass rollout with support for ‘bespoking’	*** **	Multi-borough delivery Two installation routes (procured & independent) Benchmark rates to overcome high variability in pricing	*** * **	Smart Advisor consultant Semi-targeted recruitment	*** *	Simple and flexible financial offers	***
Bristol City Council Green Doors / GDC	Extensive pre-construction technical surveys	***	Multi-ward delivery Sequencing Sufficient planning period Pre-planning delivery timelines Focus on quality, to avoid remedial works	*** *** *** ** **	Exemplar homes Community Energy Partners	** **	Interest-free loans Budget from multiple funding schemes	** ***
Greater Manchester Combined Authority Little Bill/ GDC	Whole House Approach Bespoke EWI solutions Future-proofing EWI	*** ** ***	Multi-borough delivery Bulk purchasing Scaffolding co-ordination Collaborative work between 3 national contractors	*** *** *** **	Council-tenant communication strategy	*	Interest-free loans Monthly direct debit payments scheme / higher pay-back rates Full funding for most households	** ** ***
Nottingham City Greener HousiNG	Detailed design prior to installation Boilers installed before insulation Focus on quality over EWI price	*** * ***	Pre-cut-to-size insulation boards A ‘house pack’ for each home Acquisition of a local warehouse Designers and planners work closely Training for contractors	*** *** *** ** **	Early contractors-client contact Preparation of information booklet Post-construction visit	* * *	Interest-free loans Council`s long-term plans Cost evaluation included maintenance & enabling works	** *** **

Key: *Low cost impact ** Medium cost impact ***High cost impact

2-What specific examples are there of EWI Best-Practice and are these likely to be repeatable?

In spite of the limitations in measuring success and making comparisons between projects, in examining existing literature and the five case studies projects the following set of proven, a range of EWI Best-Practice success factors have been identified. This study has suggested that these have contributed to maintaining quality, and where possible, to minimising costs. While each of the exemplar case studies reviewed highlights a list of lessons learned and recommendations relevant to that unique case, certain recurring themes can be identified across them. These are presented below, based on the key technical, supply chain, funding and customer based themes that have contributed to what can be defined as 'Best-Practice' in the deployment of external solid wall insulation.

Technical Approaches

- **Using appropriate EWI materials and systems:** At the core of technical Best-Practice is the selection of appropriate materials and systems, where the process is informed by appropriate surveying and investigation techniques as well as the consideration of location characteristics. For example, the Beeches Estate in West Wales (Project 1) used a tailored EWI system designed for the climate and in the Bristol GDC case study, Best-Practice Guidance was produced for traditional buildings specific to the city.
- **Approaching EWI as a construction project:** Examples of Best-Practice were often identified in cases where the installation of EWI was viewed not as a measure but as a construction project in itself. The application of this approach, which was particularly evident the Slough Council and GMCA GDC case studies as well as across project from the Retrofit for the Future roll-out (Project 11), ensured that appropriate construction management principles were applied in planning, resourcing and implementation. In line with the Zero Carbon Hub Cost Effectiveness guide (discussed in section 2.4.4. of this report), this was more likely to support integrated installation approaches and subsequently lead to higher quality and in in the long-term, more cost effective installation. The client on Slough Council ensured that a specialist consultant was appointed to support this approach, applying this at a wider scale is contingent on the availability of funding for specialist management and consultancy roles.
- **Ensuring EWI quality through inspection and training:** A thorough 'multiple-layer' (internal and external) QA process and audit process was implemented on the Slough project , with all properties subject to a pre-install survey and an inspection regime which included walk-arounds with site personnel, reporting and collecting photographic evidence of issues observed and corrective actions taken. Training was available through the manufacturers, through an off-site programme (at training depots), an installer carding scheme involving on-site inspection of installation practices.

Supply chain and Deployment

- **Scaled and holistic delivery:** Whole-area and a street-by-street approaches are key in achieving cost effectiveness through enabling better procurement and deployment as they make the design and construction process more manageable (as highlighted in the GMCA GDC and Slough Council case studies). In addition, a holistic approach, in which whole-houses are been treated, where possible, can also provide significantly better outcomes than in cases where only standalone measures are installed (Project 11). This approach allows for economies of scale and for aspects that might impact the efficacy of EWI, such as sequencing and integrated delivery, to be considered at once. These, however, are not possible without the support of a well thought through customer recruitment approach.
- **Using standard specification:** As highlighted in the Slough project, the provision of standard specification, where feasible, for material and installation provides scope for cost reduction at scale, particularly from a procurement and supply chain perspective. The production of standard client terms and conditions can save time, effort and costs. In Haringey Smart Homes, a similar

standard approach and costing methodology was developed. The GMCA project included a wider implementation of this principle with the development of the 'Retrofit Pattern Book', where standard detailing was not only developed, but also shared as an example of Best-Practice. Replicability of this approach can be limited when a high degree of variation in the stock exists.

- **Supporting integrated contracting:** Successful projects adopted framework which balanced employing single large national contractors and multiple local ones (often through sub-contacting). This way projects can benefit from well-established supply chains and manufacturing and warehousing facilities offered by larger organisations, but also from more flexible and quick-to-respond local teams. As highlighted in the Haringey project, local teams are often perceived more trustworthy than large construction companies by residents.

Funding and Regulation

- **Early engagement with planning:** For the large scale GMCA GDC project, having planning officers on board at the start of the project made a significant difference and speeded-up some installations, as planning officers felt part of the program and approve applications quite easily. To overcome early planning challenges, Haringey Council produced guidance on the information requirements for the Smart Homes project to guide planners across the multiple boroughs involved. The production of similar guidance document with joint consensus/clarity by both BEIS and DCLG (and trickled down to boroughs) was recommended as a replicable measure necessary to support mass rollout of EWI.
- **Simplifying finance and funding:** The Haringey Smart Homes project formulated financial offer(s) which were strong and simple. Their clear '25% contribution' from the owner message moved away from the complicated Green Deal 'Golden Rule' and was in particular key for recruiting landlords. In the Nottingham Greener HousiNG case study, the archetype-based fixed price offer for private owners allowed installers to quote 'on the doorstep'.
  Providing cost guidance and benchmarks: Haringey staff, in collaboration with project Smart Advisors and quantity surveyors, developed of a set of benchmark rates for different areas of insulation, insulation materials and miscellaneous items. This schedule of rates helped to overcome the issue of high variability in pricing and different methodologies to accounting for various enabling works (e.g. scaffolding) in the quotes.

Occupant and Community focused solutions

- **Effective Client Engagement:** Valuable design lessons can be learned by engaging with occupants (as demonstrated in Projects 6, 10 and 11) , where the projects reviewed highlighted that early and effective engagement influenced both recruitment and decision-making times, and subsequently had a direct impact on project delivery, deployment and installation. Occupants were consulted and given the opportunity to contribute to the decision making process as early as possible in conjunction with the planning requirements (e.g. Slough Council case study) and show homes set up with different EWI options for customers to view (Bristol GDC and Nottingham Greener HousiNG case studies). As an extension of duty of care, consultation processes also helped councils identify tenants who had other needs and refer them to appropriate departments for additional support.
- **Creation of a simple Customer Value Proposition:** A simple and effective value proposition for potential customers that clearly communicates the value of EWI as well as the financial offering/contribution was a key aspect in recruiting and retaining customers. For the GMCA GDC, the value proposition for households to join the program was developed based on specific community needs and focused on the improvement of their overall comfort, while for Haringey the central offering of a 'better, greener, warmer' was strengthened through the simple financial customer contribution.
- **Supporting residents through independent advisor roles:** The Haringey Smart Homes case study as well as Projects 2 and 6 showcased the role and potential contribution of Retrofit Smart Advisors (Co-ordinators). As well providing valuable technical support, the Retrofit Co-

ordinator/Smart Advisor role, although a high upfront cost led to significant cost savings in terms of providing independent technical oversight, cost policing for contractors' quotes (in one case down from 120% over the average quote), communication with customers and auditing.
- **Involvement of Community Energy Groups:** CEPs can play a vital role in the engagement and recruitment of residents for EWI schemes. Through achieving community buy-in, the involvement of CEPs can help support scaled-delivery and allow residents to access key benefits of economies of scale such as lower costs and minimised disruption. For the Bristol GDC project, CEPs supported residents to undertake retrofit and disseminate learning from the projects across the target areas. Crucially, they also acted as a catalyst for the scheme by coordinating applications for funds such as LEAF and facilitating events to generate interest. Their work also empowered customers to take action on faults via a post installation QA through the CHEESE information platform.
- **Establishing trust and accountability:** Close relationships and cooperation with local authorities are important means to gain customer trust, as council delegates are perceived to be trustworthy and reliable. In Haringey, a targeted and signed councillor letter played a vital role in recruiting customers. In the GMCA GDC case study, an approach using a 'dichotomy of trust', where tenants were approached by as many parties as possible, including local authorities – was perceived as the most successful approach.

Unintended consequences and risks:
- **De-risking installation through enabling works:** The undertaking of enabling works, in particular structural repairs to properties, are an important element to consider as a failure avoidance measure. Enabling works constituted a major part of both the Slough Council and Nottingham Green HousiNG cases studies, whose building stocks included a large number of non-traditional properties in need of repair and inefficient heating systems in need of upgrading, respectively. In the BCC GDC case study, EWI related remedial works are currently being carried out on properties for work that were improperly implemented, often where structural enabling works were not carried out in the first place.
- **Futureproofing EWI:** Effective EWI installations were future-proofed through including measures such as the upgrade/ installation of communal satellite dishes, providing information and introducing changes to leasehold clauses to prevent damage to the facades. For the Slough and GMCA GDC projects, although this was an extra cost, it both benefitted the residents and can help mitigate expensive future repairs.

3-What do local authorities or other project developers see as the barriers and drivers to more widespread EWI uptake?

The analysis of existing literature and cases studies suggests that a number of drivers to the widespread uptake EWI exist for developers and local authorities. These relate to their residents as well as their asset base, and include:
- **Asset base and portfolio investment:** In addition to decreasing the environmental impact and carbon emissions of the housing stock, if implemented properly, EWI works were seen as an investment that extended the lifetime of the housing asset base. In doing so it potentially sustained (sometimes increased) both the value of their stock and the levels of habitable/viable properties within it.
- **Addressing fuel poverty**: Solid wall properties were identified by some Councils (e.g. Nottingham) as being the worst performing homes, in which tenants are most likely to be in fuel poverty and where improvement works were likely to have a significant impact on alleviating this.
- **Future-proofing homes**: EWI was identified as a means by which to prepare homes for future low temperature heating systems (heat pumps or district heat) while avoiding the creation of future problems such as overheating.

- **Resident benefits:** Energy savings and thermal comfort for the residents were highlighted as very significant drivers across all sectors. Improved aesthetics/appearance of homes and the potential subsequent increase in value were identified as especially significant for leaseholders/owner occupiers, where lower energy bills and less likelihood of rent arrears were of particular value to social housing tenants and landlords.
- **Community and area regeneration:** Area improvement was also a key aim, where EWI was employed as a streetscape improvement measure in areas that were run down.
- **Job creation:** Retrofit at scale provides the opportunity to create jobs and stimulate the local economy.

However, the analysis also highlighted a number of current technical barriers and non-technical barriers to the more widespread uptake of EWI, which can be summarised as:

- **Bespoking, detailing and remedial works:** Economies of scale can be achieved where standard detailing can be used and procurement efficiencies can be achieved. However, the replicability of this approach can be limited when a high degree of variation in the stock exists. A key barrier to the widespread deployment of EWI involves the cost associated with bespoke detailing and remedial works required for homes, particularly where properties have been altered since construction or where existing problems need to be addressed.
- **Adopting U-Values as a standard target:** Increasing ('chasing') U-Value requirements for EWI installation performance might not be financially feasible in some cases. For example, increased EWI thicknesses required to achieve a certain U-Value target might involve cost increases for structural reinforcement and detailing and may result in property access constraints.
- **Workforce and skills limitations:** Literature has suggested that there is a current limitation in installation capacity for EWI. This was further highlighted by the case studies where given that EWI was viewed as a low-skilled process and as simple energy efficiency measure (as defined through permitted development), this resulted in such issues as poor practices, transient workforces and lack of retention due to low wages and ineffective communication of detailing approaches to workers.
- **Consumer decision making processes and timelines:** Differing timing on decision-making for consumers and securing buy-in from all parties involved can often result in a more piecemeal rather than the area or street level installations required to achieve economies of scale. This issue was exasperated by the lack of available information on occupants for some projects (e.g. Haringey) which limited the ability to adopt a more targeted approach to recruiting prospective customers given the limited programme delivery timeframe.
- **Conflicting priorities in mixed tenancy properties:** In mixed-tenancy estates, areas or blocks where property occupants included both social housing tenants and private leaseholders, issues of conflicting views and priorities regarding EWI installation may arise. In general leaseholders are likely to be more wary and to oppose works due to the costs involved, while tenants tend to be more in favour as they do not incur costs (beyond a minimal rent increase) and are likely to benefit from decreased fuel bills.
- **Funding delays and timelines:** Short term funding is not conducive to sustaining the market, maintaining job security and retaining knowledge and resources within the contractors/councils. Throughout the projects analysed, working relationships were created with a number of local SMEs but are now on hold. On the Bristol GDC project, due to delays in funding the CEP were not permitted to start communications till late in the process. As a result, recruitment information leaflets to prospective customers had to be distributed within a very short time frame which impacted the effectiveness of the approach.
- **Funding inflexibility:** Structural enabling works are a key part of EWI Best-Practice, and a significant cost. Apart from a Scottish Government Fund, these costs are currently not included as part of any UK energy efficiency funding scheme.
- **HM Treasury grant budgeting rules:** HM Treasury categorisation was identified as a key hindrance to the proper resourcing of key roles on retrofit projects funded by government grants.

For example, the funds allocated to the Smart Advisor role on the Haringey Smart Homes was limited by HM Treasury grant budgeting constraints. This significantly impacted the project as it limited the budget available to carry out more targeting and increase marketing. HM Treasury flexibility is required to enable proper budgeting of key functions and roles on future projects.

- **Planning constraints and variability of requirement:** Given the visual impact of EWI, planning was in general an important challenge in its deployment across case studies (e.g. Slough and Nottingham), where the ambiguousness of Permitted Development across LAs was highlighted as significant factor (Haringey). This resulted in significant time delays as a result of the requirement for full planning applications (often on a bespoke basis) and the information required for some cases. In Slough, planning requirements led to an initial pepper-pot deployment approach where planners required that EWI be installed on some (originally red-brick blocks) before wider deployment was permitted.

4.1 Further Research and Limitations

This study has provided an understanding of what makes for successful mass deployment of EWI activity in UK and the potential role of Best-Practice can play maintaining quality and helping to achieve cost efficiency.

Due to the inherent nature of case study-based research, the main limitation faced in undertaking this work, was ability to generalise findings, where attempts to transfer this learning or key lessons for wider application can present a challenge (Yin, 2011). Furthermore, a key aspect in determining the number of projects assessed were the practical limitations presented by the project timescale.

While the study design aimed to address this through a recruitment strategy that combined appropriate selection criteria and sampling approach, future work should ideally aim to include a larger sample (it is believed that the GDC scheme funded over 24 large-scale projects across the UK) that demonstrate Best-Practice to maximise the opportunity for generalisation. Some key considerations for this include:

- To enable rigorous evaluation of projects, more consistent information needs to be made available. Within the group of projects analysed, key limitations associated with the availability and consistency of data in regards to costings and performance improvements was found.
- The findings from this work have been drawn from research with those involved in delivering the projects and would benefit from wider exploration with residents and owners (i.e. the consumers and beneficiaries) themselves.

References

Abraham, A., 2013. The final report of the Carbon Emissions Reduction Target (CERT) 2008 - 2012. Ofgem, London, UK.

ACE, 2011. Scaling the solid wall. Association for the Conservation of Energy.

Aziz, R.F., Hafez, S.M., 2013. Applying lean thinking in construction and performance improvement. Alex. Eng. J. 52, 679–695. doi:10.1016/j.aej.2013.04.008

Baker, P., 2013. External Insulation of Masonry Walls and Wood Framed Walls. NREL.

Banks, N., 2012. The Green Deal Challenges and Opportunities Installation and supply chains.

BCA, 2008. Best Practices in Commissioning Existing Buildings. The Building Commissioning Association.

BCC, 2016. Green Deal Communities Final Evaluation- Bristol City Council. Bristol City Council.

BEIS, 2017a. Household Energy Efficiency National Statistics, headline release February 2017. Department of Business, Energy and Industrial Strategy.

BEIS, 2017b. ECO: Help to Heat April 2017 to September 2018. Department for Business, Energy & Industrial Strategy & Department for Communities & Local Government.

Bonfield, P., 2016. Each Home Counts. Department for Business, Energy & Industrial Strategy & Department for Communities & Local Government.

BRE, 2016. Post Installation Performance of Cavity Wall and External Wall Insulation. Building Research Establishment.

BRE, 2015. A report on failure rates and remediation costs for external and cavity wall insulation. Building Research Establishment.

BRE, 2014a. Solid wall heat losses and the potential for energy saving. Building Research Establishment.

BRE, 2014b. External Wall Insulation Current Practice Review and Guidance for Improvement. Building Research Establishment.

BRE, 2008. Energy Analysis Focus Report. A study of Hard to Treat Homes Using the English House Condition Survey. DEFRA Publications.

Brown, P., Swan, W., Chahal, S., 2014. Retrofitting social housing: reflections by tenants on adopting and living with retrofit technology. Energy Effic. 7, 641–653. doi:10.1007/s12053-013-9245-3

CAG Consultants, Changeworks, 2016. Smart Homes Evaluation. Haringey Council.

CCC, 2010. Meeting Carbon Budgets. Committee on Climate Change.

Changeworks, 2012. Solid Wall Insulation in Scotland. Changeworks.

CHEESE Bristol, 2017. The CHEESE Project Bristol [WWW Document]. URL https://cheeseproject.co.uk/overview (accessed 5.31.17).

CIBSE, 2013. Submission on inquiry into Sustainable Construction and the Green Deal. Chartered Institution of Building Services Engineers (CIBSE).

Creswell, J.W., 2014. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE.

DECC, 2014. Domestic Green Deal, Energy Company Obligation and Insulation Levels in Great Britain, Quarterly report. Statistical release: Experimental statistics. Department of Energy and Climate Change (DECC).

DECC, 2012. Final Stage Impact Assessment for the Green Deal and Energy Company Obligation.

Densley Tingley, D., Hathway, A., Davison, B., 2015. An environmental impact comparison of external wall insulation types. Build. Environ. 85, 182–189. doi:10.1016/j.buildenv.2014.11.021

Duffey, E., 2013. The final report of the Community Energy Saving Programme (CESP) 2009 - 2012. Ofgem, London, UK.

EAGA, 2013. Evaluation of solid wall insulation in fuel poor households in the private sector. EAGA Charitable Trust.

Energiesprong, 2015. Transition Zero: White paper.

EST, 2016. Solid walls: Costs, savings and financial support [WWW Document]. Energy Sav. Trust. URL http://www.energysavingtrust.org.uk/home-insulation/solid-wall (accessed 3.31.17).

ETI, 2012. Optimising Thermal Efficiency of Existing Housing. Energy Technologies Institute.

EU Directorate, 2016. Boosting Building Renovation: What potential and value for Europe? EU Directorate General for Internal Policies.

Forman, T., 2015. Practice, policy and professional roles: unintended consequences and performance gaps in UK domestic solid wall insulation retrofit projects (PhD). Cardiff University.

GMCA, University of Salford, RED, 2017. Retrofit Pattern Book [WWW Document]. URL https://retrofit.support/# (accessed 5.31.17).

Göçer, Ö., Hua, Y., Göçer, K., 2015. Completing the missing link in building design process: Enhancing post-occupancy evaluation method for effective feedback for building performance. Build. Environ. 89, 14–27. doi:10.1016/j.buildenv.2015.02.011

Gooding, L., Gul, M.S., 2017. Achieving growth within the UK's Domestic Energy Efficiency Retrofitting Services sector, practitioner experiences and strategies moving forward. Energy Policy 105, 173–182. doi:10.1016/j.enpol.2017.02.042

Gray, D.E., 2013. Doing Research in the Real World. SAGE.

Gupta, R., Barnfield, L., Hipwood, T., 2014. Impacts of community-led energy retrofitting of owner-occupied dwellings. Build. Res. Inf. 42, 446–461. doi:10.1080/09613218.2014.894742

Hall, S., Roelich, K., 2016. Business model innovation in electricity supply markets: The role of complex value in the United Kingdom. Energy Policy 92, 286–298. doi:10.1016/j.enpol.2016.02.019

Hamilton, I.G., Shipworth, D., Summerfield, A.J., Steadman, P., Oreszczyn, T., Lowe, R., 2014. Uptake of energy efficiency interventions in English dwellings. Build. Res. Inf. 42, 255–275. doi:10.1080/09613218.2014.867643

Hansford, P., 2015. Solid wall insulations: unlocking demand and driving up standards - (No. BIS-15-562). Green Construction Board and Government by the Chief Construction Adviser.

Hong, S.H., Gilbertson, J., Oreszczyn, T., Green, G., Ridley, I., 2009. A field study of thermal comfort in low-income dwellings in England before and after energy efficient refurbishment. Build. Environ. 44, 1228–1236. doi:10.1016/j.buildenv.2008.09.003

Hopper, J., 2012. Evaluating the installation of retrofitted external wall insulation. CIAT.

Hopper, J., Littlewood, J., Geens, A., Karani, G., Counsell, J., Evans, N., Thomas, A., 2012. Assessing the execution of retrofitted external wall insulation for pre-1919 dwellings in Swansea (UK). Retrieved Univ. Salford Website Http Www Salford Ac Ukdataassetspdf File0006011-Hopper Pdf.

I-CAN, 2017. Insulation Consumer Action Network [WWW Document]. URL http://www.insulation-can.co.uk/launch-of-the-each-home-counts-bonfield-review/ (accessed 6.1.17).

Innovate UK, 2011. What is an Exemplar?

IPPR, 2011. Green Streets, Strong Communities. Institute for Public Policy Research.

Jelle, B.P., 2011. Traditional, state-of-the-art and future thermal building insulation materials and solutions – Properties, requirements and possibilities. Energy Build. 43, 2549–2563. doi:10.1016/j.enbuild.2011.05.015

Jim Kempton, 2006. Can lean thinking apply to the repair and refurbishment of properties in the registered social landlord sector? Struct. Surv. 24, 201–211. doi:10.1108/02630800610678850

Johnston, A., 2014. Local Energy.

Li, F.G.N., Smith, A.Z.P., Biddulph, P., Hamilton, I.G., Lowe, R., Mavrogianni, A., Oikonomou, E., Raslan, R., Stamp, S., Stone, A., Summerfield, A.J., Veitch, D., Gori, V., Oreszczyn, T., 2015. Solid-wall U-values: heat flux measurements compared with standard assumptions. Build. Res. Inf. 43, 238–252. doi:10.1080/09613218.2014.967977

Long, G., Roberts, D., 2017. Integrative Smart City Planning: Mid-Term Implementation Action Plan - Nottingham. European Commission within the Seventh Framework Programme.

Loucari, C., Taylor, J., Raslan, R., Oikonomou, E., Mavrogianni, A., 2016. Retrofit solutions for solid wall dwellings in England: The impact of uncertainty upon the energy performance gap. Build. Serv. Eng. Res. Technol. 37, 614–634. doi:10.1177/0143624416647758

Lowe, R., Chiu, L., Raslan, R., Altamirano, H., 2012. Retrofit insights: perspectives for an emerging industry. Institute for Sustainability.

Mahapatra, K., Gustavsson, L., Haavik, T., Aabrekk, S., Svendsen, S., Vanhoutteghem, L., Paiho, S., Ala-Juusela, M., 2013. Business models for full service energy renovation of single-family houses in Nordic countries. Appl. Energy 112, 1558–1565. doi:10.1016/j.apenergy.2013.01.010

Malone, J., 2013. The Risky Business of Covering Up. CRI Syst. Mater. 4.

Martlet, C., 2010. Solid wall insulation supply chain review [WWW Document]. Build Up. URL http://www.buildup.eu/en/practices/publications/solid-wall-insulation-supply-chain-review (accessed 3.27.17).

Monetti, V., 2016. Review of Construction Supply Chain in Building Refurbishment. REMI Project.

NAO, 2016. Green Deal and Energy Company Obligation. National Audit Office.

NCH, 2016a. Environmental Strategy 2016—2021.

NCH, 2016b. Nottingham City Homes limited governing board meeting.

NCH, 2015. What’s my contribution?

NICE, 2015. Excess winter deaths and illness and the health risks associated with cold homes. National Institute for Health and Care Excellence.

NIHE, 2014. External Wall Insulation Pilot Scheme-A Northern Ireland Housing Executive Project. Northern Ireland Housing Executive.

Ofgem, 2013. Energy Companies Obligation (ECO): Guidance for Suppliers.

Ofgem, EST, 2003. A review of the Energy Efficiency Standards of Performance 1994 - 2002. Ofgem and Energy Saving Trust.

Pacheco-Torgal, F., 2014. Eco-efficient construction and building materials research under the EU Framework Programme Horizon 2020. Constr. Build. Mater. 51, 151–162. doi:10.1016/j.conbuildmat.2013.10.058

Patton, M.Q., 2014. Qualitative Research & Evaluation Methods: Integrating Theory and Practice. SAGE Publications.

Platt, R., Rosenow, J., 2014. Evaluating the benefits of solid wall insulation. IPPR.

Power, A., 2008. Does demolition or refurbishment of old and inefficient homes help to increase our environmental, social and economic viability? Energy Policy 36, 4487–4501. doi:10.1016/j.enpol.2008.09.022

Preston, I., Mallett, G., 2017. Learnings from Green Deal Communities. Centre for Sustainable Energy & National Energy Foundation.

ProcurePlus, 2017. Insulation Material Performance and Pricing Matrix.

Purple Market Research, 2008. UK Solid Wall Insulation Sector Profile. Purple Market Research for EST.

Raslan, R., Lowe, R., Chiu, L., Altamirano, H., 2012a. Retrofit delivery-Key Findings: Retrofit project team perspectives. Institute for Sustainability.

Raslan, R., Lowe, R., Chiu, L., Altamirano, H., 2012b. Perceived occupant experience Key Findings: Retrofit project team perspectives. Institute for Sustainability.

Rosenow, J., Platt, R., Demurtas, A., 2014. Fiscal impacts of energy efficiency programmes—The example of solid wall insulation investment in the UK. Energy Policy 74, 610–620. doi:10.1016/j.enpol.2014.08.007
Rydin, Y., Turcu, C., 2013. Key trends in policy for low-energy built environments: a 20-year review. Local Environ. 0, 1–7. doi:10.1080/13549839.2013.810837
SDC, 2006. Stock Take Delivering improvements in existing housing. Sustainable Development Commission.
Sherriff, G.A., Swan, W., 2016. Greater Manchester green deal communities programme scheme exit paper [WWW Document]. URL http://usir.salford.ac.uk/42064/ (accessed 5.4.17).
Shorrock, L., Building Research Establishment., 2005. Reducing carbon emissions from the UK housing stock. BRE Bookshop, Garston.
Snolder, M., 2014. Housing Energy Retrofit Plans- Bristol City Council.
Telow, D., De Simon, L., Riffat, S.B., 2015. A case for application of vacuum insulated panels (VIPs) in high-income area solid wall buildings, in: Sustainable Energy for a Resilient Future. Presented at the 14 the International Conference on Sustainable Energy Technologies, Nottingham, UK, p. 345.
The Retrofit Academy, 2016. Retrofit Co-ordinator Prospectus.
Torcellini, P., Pless, S., Deru, M., Griffith, B., Long, N., Judkoff, R., 2006. Lessons learned from case studies of six high-performance buildings. NREL.
Trafford Council, 2014. Home Energy Conservation Act: Trafford Council. Trafford Council.
Traynor, J., Colomba, E., Ní Hógáin, S., 2016. SmartHomes – North London Retrofit.
TSB, 2013. Retrofit for the future analysis report. Report. Technology Strategy Board.
TTHW, 2012. Solid Wall Insulation and Green Deal Fact Sheet.
UKGBC, 2013. Retrofit Incentives.
Ürge-Vorsatz, D., Arena, D., Tirado Herrero, S., Butcher, A., 2010. Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary. Center for Climate Change and Sustainable Energy Policy (.
Vlasova, L., Gram-Hanssen, K., 2014. Incorporating inhabitants' everyday practices into domestic retrofits. Build. Res. Inf. 42, 512–524. doi:10.1080/09613218.2014.907682
Way, M., Bordass, B., 2005. Making feedback and post-occupancy evaluation routine 2: Soft landings – involving design and building teams in improving performance. Build. Res. Inf. 33, 353–360. doi:10.1080/09613210500162008
Wilkinson, T., 2008. Solid Wall Insulation Sector Profile. Energy Saving Trust.
ZCH, 2016. Cost Efficiency Guide. Zero Carbon Hub.
Zhou, X., Zheng, F., Li, H., Lu, C., 2010. An environment-friendly thermal insulation material from cotton stalk fibers. Energy Build. 42, 1070–1074. doi:10.1016/j.enbuild.2010.01.020

Appendices

A.1 Methodology for Evidence Review

A Rapid Evidence Assessment (REA) methodology was applied in the undertaking of this review. REA is a shorter version of a full systematic review of literature on a constrained topic which is more focused. The main principles of the more resource intensive systematic review are applied in a manner that is more suited to enabling the swift generation of information without sacrificing the quality in faster manner and appropriate for policy research (Thomas, 2013). The review will inform the subsequent case studies element of this work by:

- Defining key areas of investigation for site visits/technical analysis (e.g. social, economic…)
- Identifying key informants (process stakeholders/actors for wash-up meetings)
- Highlighting drivers/barriers to EWI deployment and identification of key knowledge gaps.
- Determining features of Best-Practice and their impact/ importance in achieving Best-Practice.
- Scoping additional case studies /determining key factors for case study coverage test

As with systematic reviews, a rapid review uses an objective and transparent approach for research synthesis thus guaranteeing robustness and minimising any potential bias in interpreting findings.

i- Search engines: The search engines utilised include both in Google and Google Scholar, as well the UCL portal access to the Web of Science Core Collection.

ii- Search terms: The key search terms, defined as per the focus of the work, were selected to inform the following topics:

- Definition of Best-Practice
- Impact of context and scale
- Barriers and drivers/unintended consequences
- Best practice materials/products: Technical details, maintenance/lifecycle and retrofit
- Best practice enablers: Regulation, financial models
- Best practice processes: Supply chain, management/coordination, construction, installation, handover and operation

These included but were not limited to the following search strings: Best-Practice in external solid wall insulation, external solid wall insulation, retrofit Best-Practice guide, External Wall insulation materials, External Wall insulation types.

iii- Inclusion Criteria: The Rapid Evidence Review involved the collection and critical analysis of existing literature, evidence, studies and data on EWI deployment through both desk-based research (including grey literature from, for example, industry reports) and expert feedback from the project stakeholder network. To enable a practical approach that would generate useful information the following inclusion criteria was set

- Publications from 2000 onwards
- Covering, relating to the UK building stock
- Focused on domestic buildings
- Written in English

As part of the review over 50 publications were reviewed and analysed to synthesize key findings on Best-Practice, with a summary table of the key projects covered within the sources included in (**Appendix A-2**) of this report.

A-2 Review project database

Code	Source	Project Name	Year	Location	Size	Ownership/Tenure	General	Retrofit Description	Funding Scheme	Costs	Performance Improvement	Best-Practice Lessons				
												Technological Solutions	Installation	Deployment	Funding	Occupants & Community
1	Hansford, 2015	Beeches Estate	TBC	Llandysul, West Wales	105 Properties	One third privately owned , two thirds owned by Tai Ceredigion & Cantref Housing Association	A mix of 2-bed bungalows & 3-bed semi-detached homes, off the gas grid & of hard-to-treat wall construction.	External wall insulation (EWI), loft insulation, draught proofing, boiler upgrades, central heating controls & associated enabling works	Welsh Government/ European Regional Development Fund scheme – ARBED (meaning 'Save') initiative	N/A	EPC before works E48, after D61 Lifetime carbon saving – 50t CO2 Annual fuel saving - £220	A detailed technical assessment was completed on each property before commencement of work to identify the most appropriate energy efficiency measures, inform the detailed design & identify the enabling works. EWI system used has been designed specifically to meet the challenges of the wet British climate & so provides extremely low water absorption & protection against algae & mould growth.	EWI system designer Solix developed bespoke details & produced drawing packs which ensured the installation contractor knew exactly what to do. The site management team, supported by the system designer, ensured that the installation was of a high quality.	Upskilling 5 local SME's in the area. Provision of training to adjoining councils with on how to use the external wall insulation system used.	Provided over £1500 benefit in kind with works on family centre.	Two members of the local community who live on the estate employed by the Welsh contractors on the scheme & trained as external wall insulation installers. Provided over £1500 benefit in kind with works on family centre. Training on the installation & maintenance of external wall insulation provided by the supply chain working on the scheme to operatives from Tai Ceredigion & Cantref, to help them with their future works.
2	Hansford, 2015	LBH retrofit	2013-ongoing	Havering, London	Over 300	LBH/private	Non-traditional construction homes including: Unity, Wates, Cornish type 1 & 2, Orlit, Stent, Scottwood & Wimpey No Fines.	External wall insulation (EWI), high performance windows & doors (bringing elements of the planned maintenance schedule forward), flat roof & mansard roof insulation, external repairs, roofing repairs, central heating upgrades &asbestos removal.	Contract procured via Places for People's Green Services Hub. Decent Homes Programme/ ECO	N/A	EPC before work D61, after work C71 Lifetime carbon savings - 30t CO2 Annual fuel saving - £270. For Cornish Flats thermal performance has improved greatly with the U value of the walls dropping from 2.36W/m2K to 0.30W/m2K.	Willmott Dixon carried out a structural survey on an initial 10% of homes to determine if structural repairs would be necessary as part of the works. Each archetype underwent a detailed technical assessment to determine the appropriate system & identify the most appropriate way to ensure performance.	Industry standard approaches would have left many thermal bridges & thermal bypasses unmitigated. The system supplier, Weber, addressed the majority of these with bespoke approaches including thermal bridge behind the fascia up to the wall plate & the lower section of the tiled gable on the Wates; around the pressed steel window reveals on the BISF; below the starter track on all properties; & between the ground floor EWI & the mansard on the Cornish 1. Thermal bypasses requiring treatment included: the cavity on the Orlits & behind the framed insulations solution on the Cornish type 2. Since a proportion of older double glazed windows did not have trickle vents these were changed to ensure good indoor air quality. The system designer developed detailed drawing packs for each archetype so that the installation contractor knew exactly what was intended. The site management team ensured that the installation was of a high quality. Details & lessons learned were included in Willmott Dixon's EWI book, so that Best-Practice could be shared across all of its sites.	N/A	N/A	Residents educated on how to alter their behaviour to maximise energy saving in the future. At the start of the project we undertook property surveys to collect resident profile data. A resident liaison officer maintained regular contact with every individual, explaining the works programme & delivery methods. Customer & Community Officer (CCO) provided support & advice to residents, in particular during the initial stages of the scheme. Residents have been fully involved from the very start; & were given a copy of the Resident Information Pack which included scheme information, key contacts & system information & the choice of an external finish out of six colours.
3	Hansford, 2015	Parkview Hub	TBC	Thamesmead	18	Gallions Housing Association (now Peabody)	18 flats & underused garages. Constructed in 1972 of precast & insitu solid concrete. Whilst the precast facade panels partially encapsulated less than an inch of insulation the predominant envelope was solid insitu concrete with inherent thermal bridges, & categorised as	Fabric first techniques, heating energy construction factory-made pre-glazed timber storey-height SIP panels, with high performance factory-finished timber board cladding, craned in to overclad the existing facades & a metal-clad roof with landlords PV roof array. Internal alterations to inhabited flats designed to be limited to making good around existing openings, & integrating new MVHR units.	Demo project in the EU-funded E2 Rebuild research network	N/A	Reductions of 80% less than existing anticipated, built to Passivhaus Enerphit standard to achieve upper limit space heating of 25kWh/m2 (to enable residents to heat their homes for around £3 per week)	Design input included thermal modelling of critical junctions to remedy cold bridging condensation problems, iterative energy modelling during the construction period as a specification change control mechanism, & detailed design information tailored to factory production. Following completion of the works a 2-year monitoring period & the fit-out of the ground floor commercial/ community uses was initiated	N/A	Project was procured via a Design-&-Build contract with Sustainable Design as contractor's architects.	N/A	Retrofit undertaken following extensive consultation with residents, designed to be delivered with residents in occupation. Employed two local apprentices on 4 week programmes, all expenses paid. Provided support in securing permanent positions with our installer partners & the application of CSCS cards. Students from local college given work experience on their project to help with NVQ.

							'hard to treat' thermally									
4	BRE, 2016	Post Installation Performance of Cavity Wall & External Wall Insulation	2011-2013	Wales	Over 300	Community Housing Cymru, Constructing Excellence in Wales & Registered Social Landlords in Wales	Investigating properties of experiencing unintended consequences related to thermal insulation works in various households across Wales.	Main focus on EWI, however, other refurbishment measures were incorporated in some buildings (mainly double-glazed windows & mechanical ventilation).	N/A	N/A	N/A	None of the schemes were assessed or surveyed prior to the installation of the EWI systems for adequate ventilation. In some cases, EWI render had deteriorated & had to be repaired, or it was never finished adequately in the first place. When undertaking external wall insulation cladding it is important that the quality of the finish is maintained & that there are no weaknesses in the finish which could allow the substrate of the wall or the insulation material to be exposed to the external weather condition.	In most cases, cold bridges were not addressed around reveals, heads & jambs etc. In some cases roof line had not been extended. This results in a verge detail that relies on flexible sealant to provide water tightness & is a common point of failure by means of water penetration. Good practice would dictate that roof line be extended by a minimum of 35-40mm passed the insulation, to provide protection to the top of the EWI system from inclement weather.	N/A	N/A	In some cases, trickle vents were found closed.
5	Byrne et.al, 2016	The Home Energy Saving (HES) Scheme,(which has been rebranded as Better Energy Homes (BEH))	2009 - 2015	Across Ireland	N/A	Private housing	An examination of the case study of the Irish government's national grant scheme to encourage energy efficiency retrofit in private housing.	The Irish government's national grant scheme to encourage energy efficiency retrofit in private housing (the Home Energy Saving Scheme - HES). This involved the improvement of existing homes by incorporating thermal insulation, efficient boilers & control upgrades.	Partly funded by the Irish government	N/A	Test cases saw reductions in heat loss of between 1.8 to 16.1 W/m² (reduction of 37-77% of average heat loss). Three out of five homes, whose heating fuel use could be monitored, experienced measurable reductions in fuel use (63% - 21%). Other homes had increased fuel use, probably due to rebound effect or increased desired comfort levels	A combination of External wall insulation, roof insulation, internal wall dry-lining, high-efficiency boilers, solar heating & heating control upgrade	N/A	N/A	2009-2011 - €4000 was granted for external wall insulation. Between 2011 to 2015 - €1800 to €3600 granted, depending on the property type & size.	Unanimously & repeatedly throughout the interviews, comfort was cited as the main, if not the sole, motivation for homeowners to undergo retrofit. The ability to retrofit was then only facilitated by having the available funds. All interviewees professed that they would not have done the works if they did not have sufficient funds. The clients interviewed would not have taken a loan or availed of other financing mechanisms had they been on offer. The degree to which the offer of a grant motivated the homeowners to retrofit was uncertain. The possibility of saving money, either through bills or the added value to the home when selling, was not cited as a driver for any of the occupants.
6	Richard Dixon, 2010	Linlithgow Climate Challenge	2008-2009	Scotland	Around 200	Private housing / community	Good example of a community group working in partnership with the Energy Saving Scotland advice centre campaign to deliver favourable prices from an installer through achieving higher conversion rates & economies of scale.	137 loft insulation measures delivered & 78 cavity wall insulations	Private	N/A	N/A	N/A	N/A	The local advice centre found an installer that secured the best deal for all tenants. Tenants could then decide if they want to take a part or not.	N/A	The community group worked closely with the Energy Saving Scotland advice centre's Community Engagement Officer to develop a series of supporting events & local press releases & door knocking. Local politicians were also engaged. The advantage of this community-driven approach is that it avoided duplication & maximised synergies between active community groups & their local advice centres. This is also a model that would be easily replicable in terms of roll-out given that every area of Scotland is covered by an Energy Saving Scotland advice centre. The advice centre's role involved securing the best deal from the installer then acting as a first point of phone contact for householders before making a referral for the installation. Promotional material is co-branded by the advice centre & the local council.

7	Genovese et al, 2013	The BIG Energy Upgrade Programme	2010 - 2014	Kirklees Council	Hundreds of households	The project was led by Kirklees Council, in partnership with 6 Local Authorities, 4 Arm's Length Management Organisations (ALMOs), 2 Social Housing Providers, Yorkshire Energy Services & the University of Sheffield.	The project included extensive use of external solid wall insulation, stimulations of the energy efficient supply chain, behavioural studies (from individual to whole community) & area based delivery of retrofit measures	The programme involves installation of energy efficiency measures & micro generation technologies in households by adopting a fully integrated, whole-house/ whole community approach. Through individual household assessments, the project identified a highly individual package of measures for each of the households & provided optimal insulation & energy control to the house. The project also worked with communities to embed behaviour change around energy consumption.	European Regional Develop-ment Fund (ERDF)	N/A	145,113 tCO2 saved	External solid wall & cavity wall insulation, internal solid wall insulation, loft insulation, under-floor insulation, a district heating scheme, draught proofing, flat roof insulation, glazing, heating controls for a new heating system, heat pumps, microgeneration measures.	N/A	Both local & national-size businesses, though many local businesses found it difficult to get involved in publicly funded projects. Moreover, the bidding process is more difficult for small businesses as they are not aware of how to access funds.	Most refurbishments received grants / loans from local authorities	Some local authorities were more involved than others: Some offered incentives to private owners & occupiers to install energy efficiency retrofitting measures in their own houses, by totally or partially refunding the cost of the installation provided by a local firm belonging to a pre-qualification list. They recognised the influence of the procurement element, as they stated that when adopting large EERS schemes, changes to procurement & qualification methodologies should be undertaken to encourage local businesses to bid.
8	External wall insulation in traditional buildings: research report 2014	Stockton On Tees	2011 - 2014	Stockton On Tees	Over 1,600	Private & social housing	A large-scale EWI project that took place in a very deprived area of England, focusing on the Parkfield & Mill Lane regions of Stockton-On-Tees, comprised of several phases	Due to the nature of the funding (See in 'General' tab), the project took place in deprived areas. This means that energy saving, while an important priority for many parties, was not the sole driver, but rather just one element in larger-scale regeneration plan, to make the area more attractive & desirable. As such, in some instances EWI on existing properties was carried out as part of larger projects involving demolition of other housing & construction of new domestic & non-domestic buildings.	CESP & ECO	In total, the CESP funding amounted to £8m.	N/A	EWI - Polyisocyanurate (PIR) & Expanded Polystyrene (EPS) insulation boards, in most cases with a silicone render finish.	N/A	Due to the size & different stages of the project, several different contractors & insulation systems have been involved in the works. It is not clear which stages of the project employed which products or application procedures.	£3.9m funding through the Community Energy Saving Programme (CESP) to tackle over 400 properties, which gradually increased to encompass a further 500 homes. In mid-2013 ECO funding was announced to tackle the towns remaining 5,000 solid-walled homes.	The project was carried as part of a whole-area regeneration scheme

9	External wall insulation in traditional buildings: research report 2014	Liverpool	2012-2013	Sefton & Bootle - Liverpool	Around 1,000	Private & social housing. There is a mix of tenure types: the social housing landlord was established in the area over 50 years ago & bought a lot of properties, so there are many streets with 70-80% social rented housing & it seems there are no wholly private streets.	The social landlord initiated their EWI project using CESP funding & worked in partnership with a local contractor, while a private company led the private project.	The buildings in question are described by the local Council as 'poor quality, low value pre-1919 terraced houses (& 1960s system built social housing) providing cramped accommodation with poor amenity space'. They have now been upgraded with EWI (among other improvements). Due to the size & different stages of the project, several different contractors & insulation systems have been involved in the works. It is not clear which stages of the project employed which products or application procedures.	CESP & social housing landlord	Overall costs - N/A	N/A	As well as standard EPS-based EWI, householders in the private scheme were offered loft insulation, heating upgrades & door & window draught proofing, with the social housing tenants being offered similar measures but also cavity wall insulation6	N/A	In private household refurbishments, pressure may have been a factor in the planning of works, which created issues with materials delivery & the constant presence of lorries, complicated by one-way streets & limited access in many cases, & materials being left in the streets. A Clerk of Works may help minimise miss-communication	Community Energy Saving Programme CESP funded c. £3m for a social housing project & c. £5m for a subsequent private housing project, with the social landlord contributing an additional £1.3m for their project. The local Council offered the possibility of additional funding through ERDF, but the social landlord felt the CESP funding to be more straightforward & so ERDF funding was not used; consequently the local authority had little involvement in the actual project once it was underway.	As the scheme involved private housing, there was no involvement from a social housing provider used to dealing with tenants, conducting resident liaison, pre-empting possible problems & informing householders of likely levels of disruption. This meant that issues such as materials delivery, mortar splashes on walls, noise from workers, scaffolding & general disruption – all issues that could have been expected but were not highlighted through consultation – led to some complaints by residents.
10	External wall insulation in traditional buildings: research report 2014	Blackpool	2012 - 2014	Central Blackpool	473	Mainly private housing (small amount of social housing)	This project involved the overcladding of mainly privately-owned houses in central Blackpool.	The first phases of the project were led by the local Council, with several different internal teams involved: Housing Strategy (which drove the project), Planning Policy, Development Control, Heritage, & Public Health & Capital Projects. Other key partners were a scheme manager & main installer, with whom the Council worked to try & utilise local labour.	Funding was provided through the CESP programme	N/A	N/A	Surveys identified those properties where EWI would have been problematic due to the condition of the external walls.	A standard EPS-based EWI system was used following selection by the contractor, comprising 90mm EPS insulation boards affixed mechanically to the walls & finished with a silicone render. EPS was selected on grounds of cost & ease to work with when applying a thin silicone finish. The EWI system was installed in conjunction with other measures in some cases, such as boiler replacements, heating installations, loft insulation, draught-proofing & other associated works. While terraced & semi-detached houses lose less heat through their walls than detached properties, EWI is logistically simpler in such properties & it is easier to achieve economies of scale.	The presence of an on-site works inspector allowed issues to be identified & rectified although not every detail can be seen prior to completion, & the Clerk of Works did identify details that could have been improved upon.	Funding was provided through the CESP programme. Quality was a priority & funding was secured through CESP for a Clerk of Works: this was felt to be key to the success of the project.	No residents were consulted during the site visit, but the Council reports positive feedback from the majority of householders. The Council involved all key delivery stakeholders, including the internal Planning & Heritage teams: this was felt to be another important lesson. Their collaboration included both meetings & site visits, which enabled them to identify the most significant aspects of the buildings & highlight areas where EWI would & would not be deemed acceptable.
11	Retrofit for the Future: analysis of cost data, 2014	Retrofit for the future	2009 - 2014	Across UK	100	N/A	R4tf enabled the retrofit of over 100 homes, with an ambition of achieving a reduction in primary energy consumption to 115 kWh/m2 /yr. or less, & an 80% reduction in in-use carbon emissions. A project aim was to analyse cost implications.	N/A	HCA & the DCLG, with the TSB	EWI average cost for supply & fit was £161. /m2	N/A	A combination of various efficiency improvements: Rigid insulation boards: EPS (expanded polystyrene), XPS (extruded polystyrene), PUR (polyurethane) or PIR (polyisocyanurate), & Natural insulation boards: timber, fibre or sheep's wool	N/A	N/A	The type of cladding specified caused cost variations: complex finishes (i.e. those that require more regular maintenance/ replacement) added expense compared to cheaper, more conventional finishes. For example, one project specified a novel insulating render system, which proved to be more expensive than conventional systems as it required more time input from the contractor (i.e. learning how to mix & apply the product).	Working closely with residents has proved to be a good indicator for a success of a project, as well as engaging residents early & frequently in the process.

A.3 Performance and Pricing Matrix for Insulation System Costing and Procurement

performance matrix

					Use		Certification and quality standards			Thermal Performance							the performance parameters								Exposure performance		
	Manufacturer	System	Category	Kind	EWI	IWI	BBA	ETA	Details/ Other	Thermal Conductivity (W/mK))	Available thicknesses	thickness required to achieve preferred U-value	thickness required to achieve minimum U-value	maximum out-turn U-value for a typical solid wall	resulting thickness	thermal performance change over time	Moisture handling	Fire resistance	dimensional stability	Maintenance requirements	Thermal mass/ decrement delay	Toxicity	Acoustic performance	Airtightness	weather limitations during installation	resistance to rain once installed	wind load capacity
To be filled in by the supplier			-	-																							
Score as % of total							15%			5%						10%	5%	5%	5%	5%					10%	10%	
minimum performance threshold																not greater than 20% performance drop over 20 years	only for the VP lot: 25MN.s/ gm or μ 5	for IWI A1s1d0,									
preferred, with quantitative value range																		for EWI A2.s2.d1									
nice to haves - qualitative - no score																											
for information																											
Guidance Notes			Select from Drop down	Select from Drop down	tick whether intended for internal or external use		Whole score will be allocated to BBA or ETA. While other certification may be of value at this stage these are not scored.			If varying for different thickness please state. Also please state whether conductivity is the design value or stated one. Score range is >0.04 = 1% <0.2 = 5%		Please provide values for a typical wall: assume a 250mm brick wall with 25mm finger cavity, starting U-value, 1.4W/ m^2.K For EWI preferred U-value is 0.15W/m^2.K^{-1}, For IWI preferred U-value is 0.25W/m^2.K^{-1} Minimum for both is 0.3 W/m^2.K^{-1}				Please state as a percentage of initial installed performance and over what time period	This value is not required for the Vapour Impermeable Lot	Please state fire performance using the European standard	Please provide us with data on issues such as shrinkage and whether this is mitigated by detailing	Please advise of cyclical maintenance requirements	This is a new area of performance assessment, please provide us with any testing or analysis you have done. Hours delay as possible unit	Please provide data on toxicity of material in use, as well as in a fire (in this case of the smoke too)	In some cases an insulation system that has a sound absorbing benefit will be useful to customers	Please advise whether, when seeking good airtightness, an additional membrane will be required.	Please advise of limitations due to weather e.g. exposure time of board in rain before rendering. temperature limits for installation	Please advise of water resistivity once installed or other performance data you have of the products performance in exposed conditions	
Internal Guidance *(to be hidden form tenderers)*							*While assuming we'd prefer certification we don't want to necessarily exclude if the product is good and ECO is not needed*									*Assuming to set degradation at the same level as PV, but this may remove Phenolic*		*will Euro standards apply externally?*	*This is a known issue with Phenolic, while unlikely that many will provide data here it is a substantial issue*		*12 hrs excellent. 8 hrs good. 4 hrs ok,*	*There are no standards available for this. Do you want to set a standard or leave it to the clients?*	*not a key feature of thermal perf. - could be amber level with a range of values, robust details*	*with the system or a separate layer?*	*resistance to rain during installation*		*Not aware of figures here, it may just be a case of knowing if it is suitable for exposed locations.*

		Buildability							Environmental degradation					Services	External finish	References	Notes
	assumed wastage on site	**Lifetime**	**surface preparation**	**Base coat?**	**pull out test**	**limitations on substrate**	**ease of damage on site and installed**	**Applicable below DPC level**	**Global Warming Potential**	**Embodied Energy**	**manufacture**	**disposal**	**recyclability**	**Calculations/ simulations provided**	**Cladding & rendering**	**links to products' literature**	
To be filled in by the supplier																	
Score as % of total		10%							2%	2%	2%	2%	2%	10%			100%
minimum performance threshold									not more than 5								
preferred, with quantitative value range		not less than 35 years							0 preferred	0-100MJ/kg		no leaching of toxins into groundwater	must be recyclable	score based on range			
nice to haves - qualitative - no score												biodegrade after 25 years	part of company recycling plan				
for information																	
Guidance Notes		Please advise of max lifetime of product. Also advise as to whether this data is actual use or accelerated aging tests. score <30=0, >50=10%	Does the substrate require any preparation such as primer or removal of previous finishes?	Please advise whether product requires a base coat in all or any situation	Please advise structural performance of fixing method to assess suitability for use of product in exposed conditions	Is the product suitable for use on all substrates, if not what are the limitations?	How susceptible is the product to site damage, is there any mitigation in how the product is supplied to site?	Is the product suitable for use within 300mm of ground level and below?	Base on CO2 as 1. Please provide source for data. No product will be selected if GWP>5	Please provide us with the embodied energy of the manufacture of your product.	Please provide us with details of risks and your mitigation of environmental degradation in extraction of raw materials as well as manufacture	Please provide us with details of risks and your mitigation of environmental degradation from disposal, preferred targets are shown above	Please describe how waste from manufacture, installation and at end of use is recycled. Preferred targets shown	Will the supplier provide calculations for condensation risk and cold bridging? If so what type and if any - at what cost?	Please advise on what external finishes are available for the product	Do you have standards construction details, please provide	
Internal Guidance *(to be hidden form tenderers)*									*scoring system?*	*calculation system? or comparative source*				*WUFI, THERM*			

pricing matrix

	design U-value		**surface preparation cost (if any)**	unit quantity	cost/ unit	coverage per unit	**parge/leveling coat rate (if any)**	unit quantity	cost/ unit	coverage per unit	**board/batt/ roll rate**	unit quantity	cost/ unit	coverage per unit	**base render coat if any**	unit quantity	cost/ unit	coverage per unit	**reinforcement cost (if any)**	unit quantity	cost/ unit	coverage per unit	**fixing rate**	unit quantity	cost/ unit	coverage per unit	**finish render rate**	unit quantity	cost/ unit	coverage per unit	**system only rate(3)**
			£/m²				£/m²				£/m²				£/m3				£/m²				£/m²				£/m²				£/m²
	Score as % of total		2%				3%				3%				3%				3%				3%				5%				10%
select lot	0.15 (EWI) or 0.25 (IWI)	W/m².ºK⁻¹																													
	0.3	W/m².ºK⁻¹																													

	corner reinforcement & beading	unit quantity	cost/ unit	**window reveal reinforcement & beading**	unit quantity	cost/unit	**cill**	unit quantity	cost/ unit	**eaves/verge detail cost (if any)**	notes	**joining to lower roof**	notes	**plinth/at ground (if any)**	unit quantity	cost/ unit	**all in system rate(1)**	notes
	£/lm			£/lm			£/lm			£/lm		£/lm		£/lm			£/m²	
	3%			3%			3%			3%		3%		3%			50%	100%

A.4 Methodology for Case Study Reviews

For this part of the work we aimed to firstly identify a number of illustrative projects based on a targeted recruitment approach informed by the findings of the evidence review, then develop an effective strategy by which to interrogate and analyse them. This aimed to support the provision of in-depth feedback on the drivers and barriers to achieving Best-Practice in a real-life context, while highlighting the complex processes and interactions that underpin it. This was applied within a concurrent mixed- method framework for data collection and analysis Identification of case studies (Creswell, 2014).

A.4.1 Identification of Case Studies

A multi-case study design (Gray, 2013) was used to investigate the strategies, mechanisms and processes that influence the outcomes of the deployment of EWI in the housing sector. As such, the case study recruitment strategy combined appropriate selection criteria and sampling approach developed to identify ‘exemplar’ schemes that both demonstrate Best-Practice and maximise the opportunity for generalisation.

i. Selection Criteria

The recruitment of the case study projects to be assessed was undertaken through a ‘coverage test’ based on key selection criteria to ensure that they cover the main techniques and processes for EWI and reflect diversity along the lines of the following characteristics highlighted as of interest to BEIS:

- ***Social diversity:*** This aimed to include a range of tenure and household types across the projects analysed to enable the capture of the impact of the funding and engagement strategies employed and the diversity of occupancy mixes. As such the project included both owner occupiers, private rental and social tenants in both single family and multi-occupancy homes. It should be noted, although not the main target of the schemes, families identified as being fuel-poor were also included as part of some of the projects covered.
- ***Levels of participant engagement:*** The willingness of project team members in project in wash up meetings and provide available information was considered a key ‘exemplar’ indicator of the way the project was run determinant to ensure that the analysis was both thorough and useful.
- ***Data quality:*** Based on previous experience, the availability of consistent and adequate data across the case studies often presents a challenge in itself. For this analysis, projects were selected on the basis of the quality and diversity of information available from the diverse range of project partners participating in the meetings. This included both information provided by the stakeholders (documents, reports and anecdotal evidence covering both social and technical aspects) as well as information gathered from publically available sources.

Key challenges in fulfilling each of the abovementioned criteria, when experienced, across case studies will be discussed in the relevant sections, highlighting key lessons for future implementation of schemes.

ii. Sampling approach

To maximise the usefulness of findings, in addition to the aforementioned selection criteria employed, a maximum variation purposeful sampling approach was applied in the selection process. When working with a smaller sample size, once the selection criteria have been met, this approach allows for key issues that cut across cases to emerge out of the heterogeneity.

Based on the application of the selection criteria and sampling approach, five projects were purposefully selected from approximately 12 EWI projects collated for review and consideration around the UK.

A.4.2 Implementation of Hindsight Reviews

Understanding the processes impacting EWI deployment is important for learning and innovation. To enable this, Project Hindsight Reviews were undertaken for each of the selected projects. Hindsight reviews are generally classified as a ‘Learning from Experience ‘post-construction/ occupancy evaluation technique. In general this category includes approaches that aim to bring together stakeholders to discuss what they are about to do (foresight), what they are doing (insight) or what they have done (hindsight). The post-project (hindsight) review workshops were first devised by the Higher Education Design Quality Forum (HEDQF), initially for university buildings but are now being used more widely to provide opportunity for a properly structured wrap-up of lessons learned for future collaboration (Göçer et al., 2015) (Way and Bordass, 2005). As the main component of the analysis, the format, participants and procedures involved in hindsight reviews are detailed below.

i. Project meeting format

The format of hindsight reviews allows participants in each project to identify the important lessons learned during the project up to the point of completion and occupation. This makes it possible to build up a detailed understanding of the overall project strategy with a particular focus on EWI.

The main participants in each of the projects (i.e. project consortia partners) were invited to discuss the project using a pre-prepared agenda as a guide for discussion (**Appendix A-5**). The key aspects examined included the resident/tenant experience, the lessons learned in terms of the overall design challenges and viability of different solutions, the assessment of opportunities for future improvement for building technologies and construction materials, the identification of novel solutions and business development opportunities and the role, impact, challenges faced and suggested solutions relating to building control and planning requirements with regard to the retrofit process.

Hindsight reviews, ideally, need to be facilitated and chaired by a third party whom is independent of the project team and able to aid in keeping the conversation moving forward in a constructive way. This helps ensure any contentious issues don't overly dominate the conversation and all parties have a chance to contribute their perspective on how the process worked.

ii. Meeting participants

Participants in these meetings were sampled based on the 'key informants' identified as part of the evidence review undertaken for this project and are discussed in more detail below. Typically these include the property owner (e.g. developer, housing association...etc.), designer, site co-ordinator, quantity surveyor, environmental consultant, contractor/sub-contractors, finance team and in the case of housing association/LA projects, a tenant liaison officer or similar contact person.

To incorporate wider perspectives, where feasible, complementary interviews were undertaken with key industry individuals with specific expertise in key areas to supplement meeting findings. The following table summarises the profiles of the hindsight review meetings and interview participants and highlights the areas of expertise of each.

Meeting/ Interview	Participant Code	Role	Expertise				
			Technical	Supply Chain & Deployment	Occupant & Community	Regulation & Funding	Risks/ Unintended Consequences
Slough Council	PSC1	Client					
	PSC2	Client/Project Manager					
	PSC3	Surveyor/Consultant					
	PSC4	Surveyor/Consultant					
	PSC5	EWI Manufacturer					
	PSC6	EWI Manufacturer					
	PSC7	EWI Installer					
	PSC8	EWI Installer					
Haringey Smart Homes	PHC1	Client/Project Manager/Specialist					
	PHC2	Client/Project Manager/Specialist					
Bristol City Council Green Deal Communities	PBC1	Client/Project Manager/Specialist					
	PBC2	Community Energy Group					
	PBC3	Surveyor/Consultant					
	PBC4	Community Energy Group					
	PBC5	Client/Project Manager					
Greater Manchester Combined Authority GDC Scheme	PMC1	Client/Project Manager					
	PMC2	EWI Installer					
	PMC3	EWI Installer					
	PMC4	EWI Installer					
	PMC5	EWI Designer/Installer					
	PMC6	EWI Installer					
	PMC7	EWI Designer/Installer					
	PMC8	Client					
	PMC9	Client					
	PMC10	Client					
Nottingham City Council Greener HousiNG	PNC1	Client/Project Manager/Specialist					
	PNC2	Client/Project Manager/Specialist					
	PNC3	EWI Manufacturer					
	PNC4	EWI Manufacturer					
	PNC5	EWI Installer					
Interviews	IP1	Consultant (Performance)					
	IP2	Consultant (Costing & Procurement)					
	IP3	Consultant (Retrofit Advisor)					

A-5 Project Hindsight Review Meeting Material

A-5.1 Meeting Agenda

Understanding Best-Practice in deploying external Solid wall insulation (EWI) in the UK housing sector

Hindsight Review Meeting:

Location:
Building
Street
City

Date: xx/xx/17

Time: 10:00- 12:00

Meeting Attendees:

Name	Organisation	Role
Name 1 (N1)	Company 1	Client
Name 2 (N2)	Company 2	
Name 3 (N3)	Company 3	
Facilitator 1 (F1)	Organisation 1	Facilitator
Facilitator 2 (F2)	Organisation 2	Facilitator

Meeting Agenda

1. Introduction : Introductions, rules of procedure, confidentiality (2 mins)
2. What is your understanding of Best-Practice? Prompt identification of key lessons (5 mins)
3. Pre-retrofit property & design intent: (7 mins)
    - Description of the project: Overview & constraints
    - What was expected to be delivered?
    - Funding overview
4. Design, procurement & deployment (15 mins)
    - Overview of approach & responsibilities
    - Insulation strategy: Which materials & systems?
    - Specification & sourcing: opportunities for efficiencies
    - Deployment: how & why?
5. Installation (15 mins)
    - Approaches & site practices: process & management, contracting arrangements
    - Sequencing: openings & other fabric
    - QA procedures: Pre & post installation standards/quality maintenance
6. Occupants & Community (10 mins)
    - Who were they?
    - Value propositions: How were they brought on board?
    - Communications & engagement: Pre & post deployment
        - How was this handled
        - How was it received by tenant/occupant
        - Feedback loops?

7. Costs (15 mins)
    - Cost Certainty: Actual costs vs budget & detail available for reporting
    - Cost impact: Which aspects- product, process, design, other
    - Economies of scale: scope for costs reduction
8. Construction reality: barriers & challenges (10 mins)
    - Construction success stories-what went well & WHY
    - Construction difficulties-what was difficult, WHY & how was it overcome
    - Were there any opportunities for scaling up?
9. Wrap Up: Outcomes (10 mins)
    - Were the projects improved? performance, costs, bills, value, appearance
    - What was the most successful aspect of the project
    - What should be repeated (reduced scope scheme for replication?)
    - What should be avoided (technologies & processes)

Proposed rules of procedure

Reproduced from 'Sharing Knowledge – a how-to manual for professional practices', David Bartholomew Associates, 2005

- A hindsight workshop is a candid, non-judgmental discussion of what went well & what went less well in a project, intended to help everyone involved do better in the future. Contributions will not be individually attributed in any write-up, & nothing anybody says will be held against them in the future.
- Everybody's contribution is equally welcome & potentially valuable; everybody is encouraged to contribute, but nobody is obliged to do so.
- Contributions should focus on personal knowledge. Objective facts, personal perceptions of events & the thinking behind decisions are all equally important.
- Nobody should speak on another's behalf, & speculation about other people's perceptions should be avoided.
- It is normal for people's views of events to differ: the differences often reveal where performance could be improved. There should be no attempt to find out 'who was right': normally, all views are legitimate reflections of the circumstances of the original experience.

Criticism must be avoided; equally everyone should wear a 'tough skin' & avoid interpreting as criticism perspectives which

A-5.2 Project Information Sheet

Understanding Best-Practice in deploying external solid wall insulation (EWI) in the UK housing sector

Project Information Sheet

This project, commissioned by the **Department of Department for Business, Energy & Industrial Strategy** (BEIS) aims to gather evidence of EWI Best-Practice in the UK by considering case-studies, & research & innovation work, & undertaking interviews with practitioners, researchers & other stakeholders. For more information: https://iris.ucl.ac.uk/iris/browse/researchActivity/19700

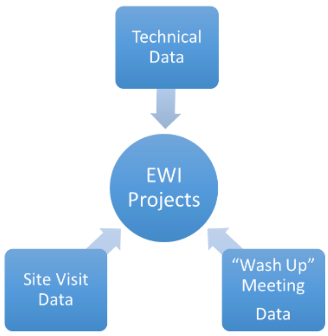
Role of University College London:

University College London Institute for Environmental Design & Engineering (UCL IEDE) is working with Cambridge Architectural Research (CAR) as the delivery partners for the BEIS ***understanding Best-Practice in deploying external solid-wall insulation in the UK housing sector*** project, assigned the task of reviewing & analysing of the results of a number of 'exemplar' EWI deployment projects around the UK which are one of the key elements of the project. For more information: https://www.ucl.ac.uk/bartlett/environmental-design/

UCL IEDE Institute will undertake an in-depth analysis of 5-6 exemplar EWI deployment projects. The main analysis tasks will include

1. Identification of exemplar projects
2. Analysis of the project technical data
3. Running & facilitation of hindsight review/'wash-up' meetings & production of highlight report

This data will be triangulated to produce an in-depth case study report for each (anonymised) project.



What are hindsight review meetings?

These meetings are a valuable tool for re-examining projects after completion & provide a forum where the multi-skilled project teams can discuss project objectives & identify important lessons learned to the point of completion & occupation. Ideally, for each project key delivery partners will participate in a round table discussion, project reports will be produced for your organisation's dissemination & learning, providing an opportunity for your work to be showcased to various stakeholders.

- Format: A pre-prepared agenda will be used as a guide for discussion with key project information, as well as evidence gathered provided by project team members. Meetings are facilitated by a trained UCL/CAR expert
- Duration: The meeting usually lasts about 1-1:30 hrs.
- Location: Our team usually travels to a location identified as being convenient to participants & try to undertake site visits shortly before/after each meeting
- Participants: These typically include the property owner (e.g. developer, housing association), designer, site co-ordinator, quantity, surveyor, consultant, contractor/sub-contractors, finance team & in the case of housing association/LA projects, the tenant liaison officer....etc.
- Examples of hindsight review meetings: We have undertaken a number of these meetings for several projects, including a number of Retrofit for the Future properties (reports can be accessed here).

Exemplar Project Information

If you have any **information or data** pertaining to your project, I would be grateful of that could be sent directly to r.raslan@ucl.ac.uk or upload it to the project dropbox (please email for access):

In particular, we would be very interested in the following types of information:

- Technical/installation drawings or photographs
- Testing data, before & after information/ measurements - particularly energy performance related aspects
- Cost schedules/ estimates
- Planning documents...etc.

Wash up meeting confidentiality:

University College London is required by law to comply with the Data Protection Act, 1998. It is the commitment of the College to ensure that every current employee & registered student complies with this Act to ensure the confidentiality of any personal data held by the College, in whatever medium. This Act came into force on 1 March 2000. In following these requirements adequate processes are in place to ensure that data from these meetings will be subject to the following controls:

- Consent to record meetings will be sought
- All data concerning individuals will be anonymised
- All projects will not be specifically identified in any reports
- Any recording made during meetings will be only used for the purposes of drafting the highlight report & will be only kept on UCL computers. The recordings may be destroyed if meeting participants wish after the drafting of the report.

For more information: https://www.ucl.ac.uk/legal-services/dp-overview

Main Project Contact	Rokia Raslan **UCL Institute for Environmental Design & Engineering (IEDE)** The Bartlett, UCL Faculty of the Built Environment Central House 14 Upper Woburn Place London WC1H 0NN E: r.raslan@ucl.ac.uk T: +44 (0)203 108 5972 (Internal 55972) W: www.bartlett.ucl.ac.uk/environmental-design t: @UCL_EDE

A-6 Project Review Data Sources

S	Name	Type	Description	Notes
Slough Borough Council				
1	Slough Council-Post Contract Review Notes	Report/ cost data	Post Contract Review Meeting Notes including cost data & technical drawings/specifications provided by Michael Dyson Associates Limited	Headline costings & savings data
2	01-(BISF)-7548 Typical Existing & Proposed Elevations Variant 5 - Rev A	Technical specification	Technical drawing for EWI installation detailing	CAD drawings, contains detailing
3	01-(CFRAM)-7548 (Typical Existing & Proposed Elevation- Variant 7) REV A	Technical specification	Technical drawing for EWI installation detailing	CAD drawings, contains detailing
4	01-(WNF)-7548 (Typical Existing & Proposed Elevations- Variant 1) REV A	Technical specification	Technical drawing for EWI installation detailing	CAD drawings, contains detailing
5	09-(SNW)-7548 Typical Existing & Proposed Elevations - Variant 27) REV A	Technical specification	Technical drawing for EWI installation detailing	CAD drawings, contains detailing
6	External insulation Freedom of information request	Installation data	Information provided in response to Freedom of information request to Slough Borough Council	Public Domain, Approximate figures
7	SERS Case Study - Britwell Slough	Project Overview	Provided by SERS Ltd	Headline costings data
8	SERS Case Study - Langley Slough	Project Overview	Provided by SERS Ltd	Headline costings data
9	SERS Case Study - Slough	Project Overview	Provided by SERS Ltd	Headline costings data
Haringey Council Smart Homes				
10	Smart Homes – Wall Insulation Standard Technical Details	Technical specification	Standard details for the Smart Homes project Effective 3rd December 2014	Technical specification overview
11	Case Study on Smart Home	Report	Case study overview	Headline costings & savings data. Financial modelling
12	Retrofitting Existing Housing Stock: The role of professional advice in supporting householders & installers Professional collaboration - lessons for the future	Peer-reviewed Paper	Conference paper on Haringey retrofit project- CIBSE Technical Symposium, Edinburgh, UK 14-15 April 2016	Smart advisor role analysis
13	Smart Homes Funding Rules	Costing data	Financial modelling & costing data. Consumer offering model/grant level Effective 4th December 2014	Headline costings & savings data
14	Smart Homes Evaluation	Technical specification & costing data	A report for Haringey Council by CAG Consultants in association with Changeworks. Includes Performance against objectives & outputs, Programme outcomes & impacts, C02 & energy bill savings, Value for money assessment, Economic impacts, Strategic added value & Effectiveness of project delivery & learning for future projects	Costings & savings data. Financial modelling
15	Smart Homes Installers' Checklist	Technical specification	Checklist based guidance for installers	Technical specification overview
16	Smart Homes: Wall Insulation, Condensation & Ventilation	Consumer information	Guidance/advice for occupants on ventilation requirements for retrofitted homes	Consumer engagement strategy
Bristol Council Green Deal Communities				

17	Bristol City Council - Green Deal Funding Campaign & Brand Positioning Statement – 03/08/14	Marketing strategy	Mission, Vision & Values of the new energy company (for rollout of retrofit) to minimise the risk of future misalignment.	Consumer segmentation & engagement strategy
S	**Name**	**Type**	**Description**	**Notes**
18	Planning & Best-Practice guidance: a route map to help householders with their energy saving refurbishment	Policy presentation	Warm Up Bristol City-wide retrofitting initiative	Policy, programme approach
19	External render Colour choices	Consumer information/ Technical specifications	Consumer engagement boards in show homes	Technical specifications
20	Heron Road Energy saving refurbishment	Consumer information/ Technical specifications	Consumer engagement boards in show homes	Technical specifications
21	Heron Road Ventilation	Consumer information/ Technical specifications	Consumer engagement boards in show homes	Technical specifications
22	CACI Acorn segmentation	Marketing strategy	Overall raw segmentation data & mapping	Consumer segmentation
23	Housing Energy Retrofit Plans Bristol City Council	Policy presentation		Policy, programme approach
24	Graphical display of information on CACI breakdown of Bishopston/ Horfield	Consumer information/	Processed segmentation data for target deployment area	Consumer segmentation/ communication strategy
25	Bishopston/Horfield target area	Consumer information/	Processed segmentation data for target deployment area	Consumer segmentation/ communication strategy
26	Graphical display of information on CACI breakdown of Easton/Lawrence Hill	Consumer information/	Processed segmentation data for target deployment area	Consumer segmentation/ communication strategy
27	Easton targeted area segmentation	Consumer information/	Processed segmentation data for target deployment area	Consumer segmentation/ communication strategy
28	Graphical display of information on CACI breakdown of Totterdown/ Windmill Hill	Consumer information/	Processed segmentation data for target deployment area	Consumer segmentation/ communication strategy
29	Totterdown target area segmentation	Consumer information/	Processed segmentation data for target deployment area	Consumer segmentation/ communication strategy
30	Bristol GDC analysis	Costings data	Processed data from sub-sample of projects	Detailed costings
31	Bristol Green Doors: An Innovation History	Case study report	Community energy group case study	Headline costings & savings data
32	Green Deal Communities Final Evaluation	Project report		Project outcome, impact, costings & savings data
33	Contract For The Provision of Development of a scalable network of Open Homes that have made energy-saving home improvements	Regulation		Project structure, legal aspects

34	External Wall insulation	Consumer information		
35	A Bristolians Guide to Solid Wall insulation	Consumer information/ technical specification	A guide to the responsible retrofit of traditional homes in Bristol	Technical details
S	**Name**	**Type**	**Description**	**Notes**
Greater Manchester Combined Authority GDC				
36	Greater Manchester Green Deal Communities Programme Scheme Exit Paper	Project report	Update on the Greater Manchester Green Deal Communities Programme with relevant reference details for post programme.	Project outcomes, impact, costings & delivery
37	Green Deal Communities Retrofit In Greater Manchester Lessons Learned Study	Project report	Overview of project delivery & review of mechanisms	Project outcomes, impact, costings & delivery
38	Caribou case study	Case study report	Rochdale EWI case study from installation contractor	Project outcomes, consumer engagement
Nottingham Greener HousiNG				
39	Green Deal Case Study	Case study report	Clifton Estate case study-Energy Saving Advice	Project outcomes, consumer engagement
40	NCH update report	Project report	Overview of project delivery & review of mechanisms	Project impact & delivery
41	What's my contribution?	Consumer information	Information on costs & contributions for Lenton Abbey archetypes	Costings, consumer engagement
42	Environmental Strategy 2016—2021	Strategy Report	Information on project roll-out, delivery & funding	Project outcomes, impact, costings & delivery
43	Nottingham City Homes limited governing board meeting	Project report	Overview of project delivery & review of mechanisms	Project outcomes, impact, costings & delivery
44	Integrative Smart City Planning: Mid-Term Implementation Action Plan - Nottingham	Project report	European Commission within the Seventh Framework Programme report on city strategy	Project costings & financial impact projections

A7-The 10 Best-Practice Retrofit Wins

Plan

1. Team up
Partnerships between local housing providers and neighbouring councils can drive costs down. Geographic proximity and similarities between housing stocks can support scaled up delivery and procurement.

2. Harmonise planning requirements before specifications
Planning constraints may drive up costs due to the ambiguousness of interpreting planning restrictions. Ensure all planning requirements are fulfilled before construction works commences

3. Target a whole house' and 'area by area' / street-by-street approach
Retrofitting a large number of properties at the same time can allow for economies of scale, and lead to significant cost reductions and decreased disruption time compared with other deployment approaches.

Communicate

4. Engage with contractors early-on
Ensure contractors are familiarised with the building stock, its characteristics and challenges. Share construction techniques and incentivise them to be part of the schemes.

5. Ensure that the public, and your customers, are well informed
Provide a clear and simple description of planned works and timelines as well as funding offerings available. Whenever possible, enlist the support of community-based groups and trusted figures.

6. Appoint a 'Smart Advisor'
The 'Smart advisor' has a key role in recruiting costumers and in keeping costumers informed with technical support and cost auditing of contractors quotes.

Standardis

7. Aim to standardise specification
Prioritise the use of a standard specification whenever possible, as this provides scope for cost reduction, particularly from a procurement and supply chain perspective.

8. Set up a generalised pricing schedule
Use a 'pricing calculator' where the price of construction works per unit area can be estimated. Allow for price variance to narrow cost uncertainties among potential customers.

De-Risk

9. Guarantee quality to de-risk future repairs
Ensuring quality through inspection regimes and enabling works, such as structural repairs de-risks installation. These might drive up costs initially, but are a necessary failure avoidance measure.

10. Cost for 'worst case remedial works'
To avoid shortage in funds when a project has started – cost for the worst case remedial works and other softer improvements (e.g. roof repairs, structural works, new boilers etc.) before finalising the budget.