Programme Area: Buildings

Project: Building Supply Chain for Mass Refurbishment of Houses

Title: Existing supply chain review

Abstract:

Please note this report was produced in 2011/2012 and its contents may be out of date. This deliverable is number 1 of 8 in Work Package 4. It presents the 'as is' status of the current UK retrofit supply chain, taking in the full supply chain from sales, survey and design through to installation and the logistics associated with building retrofit. Whilst the primary focus of the deliverable is on the UK supply chain, a comparison with retrofit activities in France and Germany is included, this will allow additional lessons learnt overseas to be incorporated into the subsequent deliverables in Work Package 4 as they progressively refine the design of the optimum supply chain to deliver mass scale retrofit in the UK.

Context:

This project looked at designing a supply chain solution to improve the energy efficiency of the vast majority of the 26 million UK homes which will still be in use by 2050.It looked to identify ways in which the refurbishment and retrofitting of existing residential properties can be accelerated by industrialising the processes of design, supply and implementation, while stimulating demand from householders by exploiting additional opportunities that come with extensive building refurbishment.The project developed a top-to-bottom process, using a method of analysing the most cost-effective package of measures suitable for a particular property, through to how these will be installed with the minimum disruption to the householder. This includes identifying the skills required of the people on the ground as well as the optimum material distribution networks to supply them with exactly what is required and when.

Energy Zone Consortium

Optimising Thermal Efficiency of Existing housing

Deliverable 4.0 - Existing Supply Chain Review

Work Package Lead Organisation	Total Flow Limited Enterprise House Roundwood Lane Harpenden Hertfordshire AL5 3BW **Paul Cook** P) 0845 130 7927 M) 07766 463 548 E) pcook@totalflow.co.uk
Authors	**Paul Cook**, Total Flow Limited **Tim Hall,** Total Flow Limited
FAO	**Matthew Barton & Mark Scaife** Energy Technologies Institute LLP Holywell Building Holywell Way Loughborough LE1 3UZ E) matthew.barton@eti.co.uk E) mark.scaife@eti.co.uk
Issue	**Updated Issue for Final Review**
Action	☐ Accepted ☐ Accepted subject to minor changes ☐ Major re-issue required _____ Signature _____ Signature

Executive Summary

This review is part of a pioneering project to design supply chain solutions, to improve the thermal energy efficiency of UK homes on a mass scale. The research will assess the energy saving from current best practise designs and model the impact on total UK energy demand. This report, part of the Supply Chain Workpackage (WP4), is a review of current capability to deliver energy retrofit on a mass scale. It also considers the challenges for suppliers to meet residents' / owners' expectations.

Market

The key finding to date is that there is no clear retrofit market and, although interest is growing in some quarters, demand for energy efficient home solutions is limited. The social housing sector has been used to pilot design solutions but the key to mass scale retrofit in the private sector is:
To broaden its perceived value to include far more than reduced energy bills.

Products

The supply of products and materials was originally seen as a key element of this Workpackage. However it's clear that the physical manufacturing and logistics are achievable, the challenge will be to engage a cautious sector to invest in capacity and drive down cost in the key product areas of: Insulation, Doors & Windows, Boiler (or other Heat Source) and simple home energy controls.

Installation

There is a major opportunity to reduce on-site labour with careful process design and product design for installation (particularly for solid wall insulation). Three approaches to retrofit are identified: Single measure (eg: wall insulation) or, partial (extension) or whole-house. Logic dictates that whole house solutions should perform best at minimal cost, but this may not be acceptable to the owners.

Capacity & Capability

It is 'on-site' activity which has the greatest challenge for capacity and capability: Homeowners do not have a positive view of building trades and will need a greatly improved proposition from fast, professional and trusted survey and sales; to completion on-time, on-budget with minimum disruption. This requires a trained workforce numbering 10's of thousands and the programmes to develop the attitudes, skills and behaviours required to meet customer requirements.

Regulation

Regulation and the Green Deal will be significant levers to influence the market from the demand and supply sides. A major risk is that providers will wait for subsidies before moving, in the hope of benefitting from equivalents to the incentives renewables enjoy through the Feed In Tariffs (FITs).

Supply Chain Design

The next stage is to start the development of robust and scalable supply chains to deliver the Design Solutions from WP3, whilst meeting the requirements of stakeholders identified in WP5. The key issues identified are 'system supply', multi skill site teams and factory prepared kits. Some key players in the current supply chain have recognised the potential and shown interest in this is encouraging. Even so the scale of change should not be underestimated: A supply chain which delivers customer value, defect free, on time, with minimal disruption and a step change in energy consumption, at the rate of a home per minute for the next forty years, at half around today's cost.

1.0 Introduction and Objectives

Work package 4.0 Studies the existing supply chain in retrofit activity.

Deliverables are:

- A visual representation of the existing supply chain with both qualitative and quantitative information from stakeholders
- Develop metrics for:
  - Performance
  - Capability
  - Volume
  - Investment criteria
  - Regional Coverage
- Review with key Stakeholders included in this report.
- Review with other Stakeholders and collect reactions

2.0 Methodology

- Identify and engage Stakeholders
- Define scope of products and services to be considered
- Gather data on supply chain capacity and performance
- Interviews Stakeholders to provide an “as is” view of the supply chain.
- Collate and interpret data and present visually
- Review supply chains in France and Germany and contrast with the UK
- Desk research of thermal efficiency materials & labour required for a whole house retrofit.
- Identify future work needed to complete the picture of the existing supply chain
- Detailed review with Key Stakeholders

3.0 Stakeholders

To give a wide range of viewpoints stakeholders were approached from householders; through the supply chain to regulators and funding organisations as listed in Appendix 1. The major emphasis was on representation from each of the following categories:

- Installers, Trades people, Specialist Contractors
- Manufacturers’ data – products , systems, components and raw materials as in Appendix 2
- Trade bodies, Stockists, Distributors, Logistics and delivery companies,
- Financiers, Insurers,
- Energy providers, Utility Companies,
- Local Authorities, Building control officers, Training providers
- Householders, Community Housing associations, Architects, Designers, Specifiers

Companies were contacted initially by email invitation to participate, telephone interview and face to face meetings. A list of participating companies / trade bodies is given in Appendix 3 and includes an indication of the level of contribution and engagement.

4.0 Scope

At the project level the goal is to clarify the conditions under which the mass retrofit market can deliver carbon savings cost effectively. The supply chain to achieve this will include the elements in Figure 4.0.1 below.

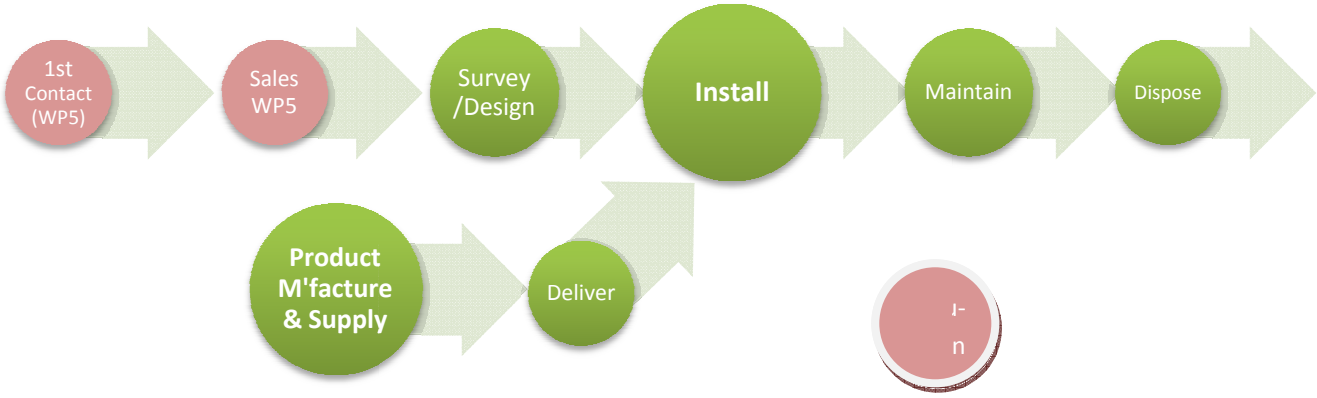


Figure 4.0.1 – Supply Chain Visual

Products and Installation elements are expected to have the most impact on the energy performance and customer value respectively and will form the bulk of the analysis. Logistics and delivery are the most easily scalable elements of supply and are not seen as a major constraint. There is limited data available for the maintenance and disposal of energy retrofit solutions and so these elements will be discussed qualitatively.

4.1 Sales, Survey & Design

The initial contact with the householder and sales activity are part of the customer value proposition and, although the current routes are described below, the market drivers are covered in detail within WP5. These will have a significant input into the future supply chain design.

4.2 Materials

Materials required to complete a retrofit include everything from insulation to screws and paint. To avoid getting lost in detail the following classifications have been adopted based on the products' impact on the thermal performance of the retrofit.

4.2.1 Primary Products:

Products which are crucial to achieving energy improvement in any retrofit:

- Insulation materials – walls, ceilings, roof, floor
- Windows and doors
- Primary heat source: The central source of space heating and Domestic Hot Water (DHW)
    - This will include Boilers (irrespective of fuel), Heat pumps (air and ground source) [▽]

4.3 Secondary Products:

Have an impact on thermal performance, but may only apply for certain retrofit solutions (will be covered in less detail than primary)

- Solar thermal water heating $^{\nabla}$
- Energy management systems
- Ventilation and Heat recovery systems
- Spot water heating (instant water heaters for basins / sinks)*
- Electric showers *

* Both the above reduce hot water "dead leg"; the volume that needs to be run before hot water arrives at the tap from boiler or tank. They also play a part in making optimum use of lower temperature water from heat recovery and solar thermal or heat pump outputs.

$^{\nabla}$There is parallel research, funded by ETI, working on Heat pump and solar thermal performance and as a result the performance characteristics of these products will not be part of the scope.

4.3.1 Tertiary Products:

Play little part in thermal performance, although likely to be part of the retrofit.
(These will only be considered where supply issues might put at risk the success of mass roll out)

- Products for decoration post refurbishment
- Trade supplies (flooring, timber, plasterboard etc.)
- Low Energy Lighting

4.4 Installation & Logistics

For clarity 3 approaches to installation have been defined:

- **Single measure** (eg: Cavity Wall Insulation / Double Glazing etc.)
- **Partial retrofit**: Multiple measures installed for part of the property (eg: Extension / Loft conversion)
- **Whole House**: The property is treated as a 'whole system' with all elements balanced to give optimum energy performance.

Today there are few examples of whole house energy retrofit and so contrasts will be made with similar large scale programmes (eg: CLG Decent Homes) as well as the capability of single measures and partial retrofit.

The logistics of getting material and people on site will be covered where it ha a significant impact on mass scale retrofit.

4.5 Regulation

The regulatory environment can have a major impact on the speed at which the supply chain adapts to new opportunities. This operates is opposing ways:

- Incentives can stimulate new markets and encourage growth, but in complex ways which have unintended consequences.
- Regulation can ensure consistency and standards, but at the same time create bureaucracy and delay in the take-up of initiatives.

The current regulatory environment is covered in detail in WP 6.1, but aspects will be included here where it has a direct influence on supply chain.

5.0 Review of Existing Supply Chain Elements

As covered briefly above there is currently no retrofit supply chain of significant scale. To achieve a meaningful picture of the capability to deliver retrofit on a mass scale; a review of each element is needed.

5.1 Sales Channel: Including Survey & Design

To have a market for retrofit there needs to be a perception of its value. At this point energy performance of a home is neither well understood nor highly valued. Home Information Packs were intended to raise the priority of energy performance amongst householders and Estate Agents, but this has not proved to be the case. Further work will be carried out in WP5 on defining customer value, and linking to WP6 on regulation and incentives.

Housing tenure has a big impact on the uptake of Home Improvement including energy efficiency. In the Owner Occupier sector improvements to kitchens, bathrooms and windows dominate, with little emphasis on energy saving as a driver; although this is growing. The CERT initiative (Section 5.5) has also been a route to stimulate demand through subsidised measures.

5.1.1 Social Housing

Social Housing has the largest whole house retrofit at around 100,000 homes per year (Wates). The focus of these interventions is moving from decent homes standards (Kitchen, bathroom, doors & windows) towards energy retrofit. Social Retrofits are completed to a high standard and become viable based on 'street by street' completion to offset the high cost of 'prelims' (site & project management, amenities, material compound and profit).

Responsibility for design solutions in social housing is generally passed on to subcontractors and included in their costs. Where a condition of planning Wates use external architects, costs can be spread across multiple dwellings and can be covered within the prelims at a rate of between 3 and 5% of installed cost.

5.1.2 Energy Companies

As part of their obligations under CERT (see 5.5) energy companies are obliged to encourage take-up of energy saving measures. Most choose to act as a portal for accredited providers of insulation rather than carry out the work themselves. These are currently on a measure by measure basis rather than whole house.

- **High Volume Measures**: Loft / cavity wall insulation, (Solid wall insulation growing)
- **Market Material Subsidy**: DIY Insulation, Low energy bulbs, Low-e Glass
- **Demonstration Measures**: Solar thermal, Heat Pumps, Photo Voltaic (PV)

Other than for material subsidy; market feedback has been that demand frequently outstrips capacity and response times are seen as inadequate in many instances. Other frustrations include the classification of homes as 'Hard to Treat' and so unsuitable for the discounted intervention based on having belongings or floorboards in the attic space. There is little evaluation of energy improvement post completion.

5.1.3 Specialist Installers

The Repair, Maintenance and Improvement (RMI) market covers a broad range of suppliers:

- Small, private window fabricators / installers who may fit as few as twenty windows/week
- Kitchen and Bathroom specialists.
- National brands, franchised and owned, covering windows, doors and conservatories. More recently moving into energy efficiency measures (insulation, solar thermal, PV) as the glazing market is saturated with corresponding lower margins.
- A growing number of Insulation specialists through the NIA (National Insulation Association) and TICA (Thermal Insulation Contractors Association).

The Energy Saving Trust offers links to trade bodies for specialist energy saving measures.

Survey and design are generally offered as a free quote or estimate, typically with a conversion rate of less than 50% making survey and quotation a high cost burden.

Customer satisfaction is an increasingly important driver for winning repeat business and to shake off the reputation of 'cowboy' building trades.

5.1.4 Whole House Retrofit

The whole house energy or eco-refurbishment market is growing from a very small base. Demand comes from wealthy, energy conscious homeowners and is particularly prevalent with historic buildings. Almost exclusively energy retrofit is introduced as part of a major refurbishment; rather than as an intervention on its own right.

Other than DIY Self-Refurbishment There are two common routes:

- Architect led refurbishment – Homeowner selects an architect to design and project manage based on a tender process.
- Retrofit Specialists - Survey and design are part of the quotation process and to reduce the number of 'time wasters' a chargeable Energy Audit and Plan is common.

5.1.5 Do It Yourself (DIY)

In the DIY market the subsidies on insulation products, such as loft insulation and draught proofing systems, have stimulated increased adoption of home insulation. Retailers provide 'How to' information for the use of insulation products but 'whole house' guides for DIY (& jobbing builder) retrofit (e.g. CPA retrofit link in Appendix 2) are not widely distributed. These are important to help householders prioritise their interventions and make them aware of the potential negative consequences of energy saving (dampness, mould growth).

5.2 Products & Materials

Products for energy retrofit were, until recently, largely anonymous: Performance of insulation and boilers played no part in a householder's decision process. Although energy ratings for boilers and windows are less well understood than for white goods; awareness of varying performance is growing and markets are shifting towards A rated products. In insulation two leading manufacturers have raised their brand profiles and are increasingly using 'green' 'eco' & 'sustainable' as part of their marketing.

5.2.1 Primary Products

<u>Insulation:</u>

As can be seen from figure 4.0.2 there is a broad range of materials for building insulation.

Figure 4.0. 2 Range of Insulation Products Currently Available

The two key performance metrics are thermal conductivity & U-value, as shown in Figure 4.0.3 below.

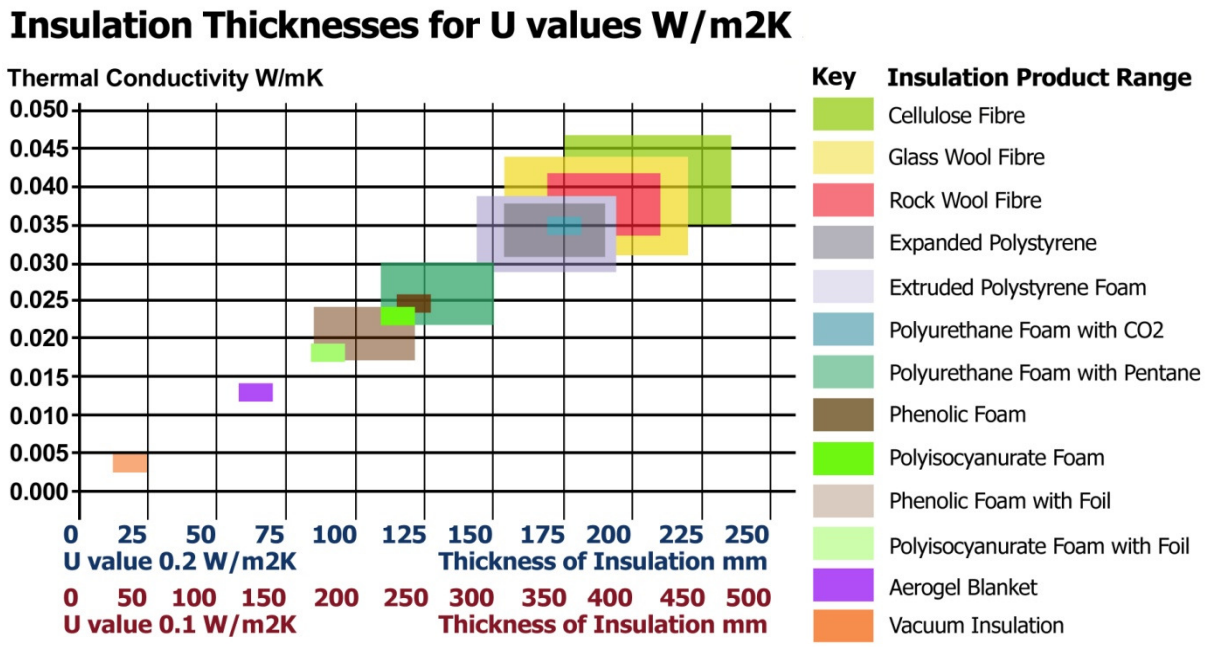


Figure 4.0.3 Range of Insulation Performance by thickness

As can be seen from the graph the thermal conductivity can have an order of magnitude impact on the thickness required to achieve a particular U-Value. In 'cold' loft spaces thickness may not be an issue, but for internal solid wall insulation the loss of 300mm of room space to achieve a U-value of 0.15 would be highly significant.

Installation is critical to achieve design performance: Cavity wall fill relies on both a good quality cavity to allow material to flow and careful process control from the filling team. Performance of Multifoil insulation is reliant on achieving an airtight barrier which is difficult to achieve on exposed sites or in cramped conditions.

Some foams absorb water, fibres allow water into their structure; both have a significant impact on the theoretical thermal performance in cavity walls.

The newer high performing Aerogels and Vacuum insulation products have been proven in other industries but have not been applied and tested in volume in construction applications.

Not all these products have the same supply model or capability. A qualitative summary of the differences is presented in Table 4.0.1 below.

Doors & Windows

Replacement windows have been a highly successful Home Improvement; comfort (reduced draughts) and home value were the initial drivers. Now there is increased awareness of the A-E energy ratings and this has shifted 20% of the market to A rated or higher.
The same is not yet true for doors where energy efficiency has not been a marketing priority.

Primary Heat Source

Until recently the majority of replacement boilers were distress purchases to replace faulty equipment. The mandatory improvements in combustion efficiency, coupled with the boiler scrappage scheme has created a step change in products and raised consumer awareness. This scheme resulted in 118,250 boiler replacements. (Source Energy Saving Trust UK)

Product Capability Comparisons

The following summary table is designed to give an overview of the capability products and materials to contribute to significant thermal energy reduction (targeting 80%) in existing homes.

It is a summary based on published performance data, installer feedback and peer review.

Table 4.0.1: Existing Supply chain Product Performance

	Supply	**Performance**	**Environmental**
Product	**Supply maturity / capability**	**Thermal Performance**	**Ease of installation / dust / disruption**
SUDG Windows	✔ ✔ ✔	✔ ✔	✔ ✔ ✔
A* Rated SUDG Windows	✔	✔ ✔ ✔	✔ ✔ ✔
Doors	✔ ✔ ✔	✔ ✔	✔ ✔ ✔
Cellulose fibre	✔ ✔ ✔	✔ ✔	✔ ✔ ✔
Glass Wool Fibre	✔ ✔ ✔	✔ ✔	✔ ✔
Rock Wool Fibre	✔ ✔ ✔	✔ ✔	✔ ✔
Expanded polystyrene	✔ ✔ ✔	✔ ✔	✔ ✔
Extruded Polystyrene foam	✔ ✔ ✔	✔ ✔	✔ ✔
Polyurethane Foam +CO2	✔ ✔ ✔	✔ ✔ ✔	✔ ✔
Polyurethane Foam with Pentane	✔ ✔ ✔	✔ ✔ ✔	✔ ✔
Phenolic foam	✔ ✔	✔ ✔ ✔	✔ ✔
Polyisocyanurate foam	✔ ✔	✔ ✔	✔ ✔
Phenolic foam with foil	✔ ✔	✔ ✔ ✔	✔ ✔
Polyisocyanurate foam with foil	✔ ✔	✔ ✔	✔ ✔

Product	Supply maturity / capability	Thermal Performance	Ease of installation / dust / disruption
Aerogel Blanket	✔	✔ ✔ ✔	✔
Vacuum Insulation	✔	✔ ✔ ✔	✔
Condensing boiler	✔ ✔ ✔	✔ ✔ ✔	✔ ✔
Heat pump	✔	✔	✔
Solar thermal	✔ ✔	✔ ✔ ✔	✔
Biomass boiler	✔	✔ ✔ ✔	✔

SUDG: Sealed Unit Double Glazing An expanded matrix is shown in Appendix 4

✔ Currently **Insufficient** capability to achieve significant energy reduction at scale.

✔ ✔ Capable of **contributing to** achieve significant energy reduction at scale.

✔ ✔ ✔ **Fully** Capable of achieving significant energy reduction at scale.

The data in Table 4.0.1 is an amalgamation of research from structured interviews from across the construction supply chain. In some instances there were conflicting views and there was a general lack of consensus or data to support individual views. This reinforces the authors' assertion that future retrofit supply should be built from a set of market requirements; not reliant on capability of current elements.

Key Points From table 4.0.1

- Windows & doors have capacity, but need to migrate to lower U-value products.
- There is currently no single insulation material which is fully capable across all criteria.
- There is additional installed capacity above demand for the more established products.
- Leadtimes for capacity uplift is up to 24mths for new products which require approvals.
- Ease of installation is a challenge for all insulation products (including cavity fill).
- Condensing boilers have a major part to play, installation would score higher but for issues of effectively linking with existing systems and adding more intelligent controls.
- Biomass boilers may prove highly efficient but there are issues with size and material supply which will make them unlikely to be more than a niche contributor to retrofit.

5.2.2 Secondary & Tertiary Products

Solar thermal water heating

There is advantage in using solar energy to increase the incoming water temperature from around 9 degrees Centigrade to reduce the energy requirement from other sources to heat domestic hot water, installation difficulty and the economics of such installations plus resulting payback period are not clear cut which results in this being considered a secondary product.

Ventilation heat recovery

Installation of ventilation heat recovery systems is considered complex and disruptive with relatively high maintenance requirements, unclear benefits in reducing energy demand for home heating. The exclusion of ventilation heat recovery will however limit the ultimate thermal efficiency which is achievable in retrofit: A minimum air flow of $5m^3/m^2$/hour is considered to be needed to maintain good health and reduce the risk of condensation and other related problems. As a result these products are therefore considered of secondary importance.

Spot water heating (instant water heaters for basins / sinks)

A large quantity of water usually needs to be run off at a basin or sink before hot water reaches the tap. When washing hands for example, the tap is frequently run for insufficient time to achieve warm water supply (the situation is exacerbated with combination boiler installations where the boiler will not run efficiently when run for such short intervals). This wastes water and energy, but this has not been shown to be a significant element of the whole house consumption and so these products will be considered to be secondary.

Electric showers

These appliances have benefits in heating only the water used during showering, however in terms of energy reduction they are not considered to offer significant improvement if the primary heat source is gas fuelled.

Tertiary Products

No tertiary were deemed to have significant supply or installation issues to warrant consideration in the supply chain map. However there are products such as low-odour paints which may contribute to improving the overall value proposition.

5.3 Investment in Manufacturing Capacity

When interviewed on the subject of investment in manufacturing capacity, all manufacturers indicated that capacity is matched as closely as possible to demand. All indicated that should extra capacity be required; the investment would be made in order to secure market share, this would either be through additional shift working or duplication of manufacturing facilities. Despite these reassurances there was little shared evidence of proactive market planning.

5.4 Installation & Logistics

After capital cost; the dominant 'sacrifice' a householder has to make when considering home improvement is the disruption during installation. The range is from vacating the property for a period of months; to having the installers work around the family in situ. Problems arise when the householders' expectations are not met and there are many 'horror stories' of building work with time, cost and performance failure. There are two key reasons:

- The difficulty in assessing current building condition and so cost and scope of works.
- Poor planning and assessment skills of tradespeople.

The former is sometimes used as a justification for failing to invest in the latter.

5.4.1 Installation Capacity

Current energy efficiency installation capacity is market driven, with some external stimuli: E.g. Cavity Wall and Loft installation have grown rapidly in response to CERT subsidy.

There is a broad spectrum of capacity across the range from Single Measure to Whole House interventions.

Whole House

Few whole house retrofits have taken place compared to the target of 7 Million homes by 2020 and there is no common definition of what constitutes a successful Whole House intervention.

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. (Wates enjoy approximately 20% of the market; carrying out 20,000 refurbishments / annum and cite availability of skills as a limiting factor).

For private households carrying out their own improvement projects there is no central record of whole house retrofit, which is starting to grow from a very low base. Finding a capable whole house specialist is difficult and those that do exist are both in high demand and at the premium end of the cost scale. Addressing this gap is one of the objectives of the 'Superhomes Network' Capacity is difficult to assess but the number of private whole house retrofits is estimated at between 1,000 & 5,000 per annum.

Partial Retrofit

The owner occupier sector dominates this area as homeowners seek to increase space for growing families or to improve the value of their property. The majority will be constructed to meet with building regulations rather than as a step change in building energy performance. This is a significant opportunity for a market estimated to be 200,000-500,000 homes / annum.

Single Measures

Individual measures are at differing stages of their cycle. Double Glazing is an example of an established measure. In the 1980's and 1990's capacity grew rapidly as demand increased (without incentives) and cost of entry reduced. The industry had a poor reputation for Customer Service which only improved in the mid 2000's with increased competition and overcapacity, also driving down both cost and margins. Installed capacity is currently around 10M windows; sufficient for 1.5M home equivalents per year.

A summary of actual single measure energy installations is shown below (NB: Actuals are likely to be lower than capacity for mature measures)

Table 4.0.2: Summary of CERT funded interventions (Augmented)

Intervention Category	**Material QTY per house**	**Number of CERT properties in 2yrs**	**Annualised Equivalent Rate**	**% of stock /yr *** (yrs to complete)
External Solid Wall Insulation	100 sq.m	20,000	CERT 10,000 Total 13,000	Total Solid Wall 0.3% (300) (based on 6M stock)
Internal Solid Wall Insulation	100 sq.m	10,000	CERT 5,000 Total 7,000	
Cavity Wall Insulation	25 cu.m	1,121,000	560,000	2.8% (35.6)
Loft Insulation	45 sq.m	Install: 1,390,000 DIY: 1,043,000	1,216,000	6.2% (16)
Windows	8 Units		1,250,000 A Rated: 250,000	Total: 4.7% (21) ARate:0.9%(100)
Doors	2 Units		1,000,000	Total: 3.8% (26) A Rated: -

Intervention Category	Material QTY per house	Number of CERT properties in 2yrs	Annualised Equivalent Rate	% of stock /yr * (yrs to complete)
Primary Heat Source (predominantly condensing boilers)	1 unit	1,200,000 Est.	CERT 600,000 Total 1,100,000	4.2% (23.6)
Heat Pumps	1 unit	1500	750	-

Source - OFGEM report 2nd year of Cert (Aug. 2010), Augmented with EEPH & Industry data

* % of Stock/yr: The % of stock likely to require this intervention completed per year at the **current rate**. ie: 20M cavity wall homes, 560k fills/yr, 2.8% completed /yr = 35.6 yrs to complete.

Solid wall insulation capacity is difficult to determine so the assumptions for this table are included in Appendix 5.

Key Points From table 4.0.2

- Solid wall treatment is well behind the required run rate to complete the 6M home stock and requires an eight fold increase in capacity to complete by 2050. 150,000/ yr required.
- There is sufficient capacity to complete all loft insulation within 16 years (less more than 2 years equivalent already done).
- Cavity wall will complete before 2050 at the current rate, and capacity is still increasing.
- Windows and doors have installation capacity but products need migrating to A Rated.
- Boilers are can be comfortably completed before 2050, but there may be a move to electric or renewable heat before that time; requiring a second retrofit at some point.

Supply Chain Capability Comparisons

The following table gives an overview of the capability across the supply chain for energy retrofit.

It is a qualitative summary based on householder, supplier, installer and peer reviews.

Table 4.0.3: Existing Supply Chain Supply Maturity Matrix**.**

Product	Survey	Sale	Distribution	Install	Maintain
Windows	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔
A or A+ Windows	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔
Doors (not rated)	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔
Cavity wall insulation	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔
Loft insulation	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔
External wall insulation	✔ ✔	✔	✔ ✔	✔ ✔	✔
Internal wall insulation	✔	✔	✔ ✔	✔	✔
Ventilation & heat recovery	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔
Condensing boiler	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔
Heat pump	✔	✔ ✔	✔ ✔	✔ ✔	✔
Solar thermal	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔
Biomass boiler	✔	✔	✔	✔	✔

✔ Immature – forming, little experience of products / few installers

✔ ✔ Products known, information available growing but relatively new

✔ ✔ ✔ Mature market, bulk supply of product / approved installation routes available

Key Points From table 4.0.3

- Windows, doors, boilers, loft and cavity insulation have mature and capable supply chains although aftersales testing of performance may be lacking.
- Solid wall insulation (internal and external) supply chains are still at an early stage and need developing.
- Although Heat pumps and Biomass boilers are seen as part of the energy mix they are have a niche role to play at this stage.

5.4.2 Logistics

Construction logistics is dominated by supply through builders' merchants, both for large and small projects. Capacity is not a constraint and easily scalable.

As a general contrast with other sectors (retail & manufacturing) logistics to site are unsophisticated with high stock (in the merchants, and in some instances on site), and a lack of optimised delivery to site: Most deliveries requested for 8:00am, frequent trips to merchants for 'missed' items. This adds to costs although these are not easily visible.

Some specialist installers have adopted more advanced 'kitting' of parts for their teams supplying just what is needed for an installation and noting any variance in material use.

For high value and made to order products; direct supply from manufacturer to site is possible, but needs to be offset with increased traffic and number of deliveries.

5.4.3 Skills & Training

A lack of availability of skilled trades is seen as a limiting factor for whole house retrofit in the social housing sector in particular. With high staff turnover there is a lack of investment in work based training and upskilling.

Construction work remains a sector dominated by single skill trades. This results in a high staff count on site adding to the disruption of the home. Productivity is also reduced as a result of the inability to balance work across trades and ensure tradesman do not spend time waiting for others. Successful specialist installers have minimised the need for multiple trades by redesigning the product (eg: Plug & play boilers) or creating multi trade teams working together.

This is where the 'off-site manufacturing sector could have a major part to play: To date the focus has been on duplicating 'wet trades' inside a factory. A more sophisticated approach which increases the speed of installation and 'de-skills' site work addresses two obstacles at once.

Site Health and Safety is a potential hazard on all but the most minor interventions. Contractors are bound by CDM regulations only when a project exceeds 30 days.

5.4.4 Installation Waste

Progress has been made to reduce construction waste to landfill, particularly for larger contractors. An objective for the retrofit project will be to minimise waste destined for Landfill by eliminating material excess and segregating / recycling site waste.

Wates have a new build objective for zero waste to landfill and are currently operating at less than 3% (Appendix 6). There is currently a lack of published data for the quantity of waste resulting from a whole house retrofit but a target of <5% to landfill should be considered a minimum target.

Disposal of current retrofit products at the end of their useful life is not highlighted by manufacturers or installers, but will form part of their 'sustainable' credentials. Whole life implications must be considered to avoid 'asbestos' like future problems.

5.5 Carbon Trading Regulation

Energy suppliers influence solutions through CERT subsidy / carbon trading mandated by HM Government. This will evolve into the Energy Company Obligations (ECO) in 2012 and augmented with private funding through the introduction of the 'Green Deal'.

Carbon trading influences the market for energy efficiency measures by allowing Energy Companies to offset the carbon they emit by subsidising energy saving products. The Carbon Emissions Reduction Target 2008-2012 (CERT): is one mechanism driving this.

- Energy Suppliers can meet up to 5 per cent of their obligation through the Priority Group flexibility mechanism. This aims to target low income hard to treat homes.
- The levy has funded Cavity wall insulation, low energy lighting, loft insulation
- It has funded 'low-e' coated glass in glazing replacement; narrowing the price difference to "Standard" glazing products. In the medium term economies of scale should narrow the gap further ultimately making 'Standard' glass obsolete.
- Suppliers can also meet a proportion of their obligation through carrying out demonstration projects, to trial new types of measures or customer reactions to information or measures

The structure of these incentives has ensured that these specific, individual measures have been delivered in volume, but there are two significant concerns for the project team:

- In targeting volume there has been little testing of the actual savings made. This could leave the UK in a position where we need to revisit properties a second time for retrofit.
- By targeting the Priority Groups the measures are likely to improve the comfort for low income users; rather than addressing the profligacy of other more affluent users.

5.6 Costs

Affordability and payback are the most important factors to develop the retrofit market beyond the 'early adopters' who are driven to do what is sustainable and have the capital to invest.

For mature (✔ ✔ ✔) Single Measures shown in Table 4.0.4 costs are well understood and reliable; with established practices despite the broad range of housing types. That is not to say that careful process design and innovation could not reduce them further.

Solid Wall insulation, Ventilation with Heat recovery and Heat Pump installation is at an early stage and has not yet been optimised. This indicates a much potential for significant reduction in costs (30% is typical). Taking the example of a 3 bedroom semi-detached property we can build up a picture of multiple single measure costs as follows:

Table 4.0.4: Single Measure Costs								
	Cavity	External	Internal	Cavity Saving/yr	Solid Saving/yr	Cavity Payback	External Payback	Internal Payback
Loft insulation topup #	£250	£250	£250	£40	£40	6.3 yrs	6.3 yrs	6.3 yrs
Cavity Wall #	£250			£110		2.3 yrs	-	-
Solid Wall		£12,000	£7,000		£380	-	31.6 yrs	18.4 yrs
Draught proofing	£200	£200	£200	£100	£100	2.0 yrs	2.0 yrs	2.0 yrs
Double glazing (single to B)	£3,000	£3,000	£2,500	£135	£135	22.2 yrs	22.2 yrs	18.5 yrs
Floor insulation	£400	£400	£400	£50	£50	8.0 yrs	8.0 yrs	8.0 yrs
Condensing boiler F-A	£2,000	£2,000	£2,000	£145	£145	13.8 yrs	13.8 yrs	13.8 yrs
Total Cost	£4,100	£15,850	£10,350	£580	£850	7.1 yrs	18.6 yrs	12.2 yrs
Heat pump *	£8,000	£8,000	£8,000	-	-	N/A	N/A	N/A
Source: Energy Saving trust (augmented)								
# Costs based on CERT subsidy		*Heat pump figures only for contrast: Not included in totals						

Table 4.0.4 shows the levels of investment needed for multiple single measures. It demonstrates the effect of subsidy in bringing down the payback period (0% inflation and cost of capital). The total annual savings (based on Energy Saving Trust - EST data) seem optimistic based on a typical annual energy bill of £1200. If correct these measures should deliver a 50% or 70% saving for cavity and solid wall respectively. There certainly demonstrates an element of double counting, particularly as performance of individual measures is unlikely to match that of a whole house retrofit. Actual retrofit performance is covered in detail in WP 3.2 and forms part of the Dwelling Energy Model WP 1.

For Partial Retrofit Loft conversions costing between £14,000 and £50,000 are a major part of the market. Extension costs are highly dependent on the increase in area undertaken but the Royal Institute of Chartered Surveyors (RICS) average cost is between £30,000 and £50,000. The additional costs and energy savings from putting energy measures at the core of such works have not been documented, although logic dictates that this will be marginal compared to the building of new space. Therefore the payback of adding additional insulating material and higher specification products will have a faster payback than if the measures are taken in isolation.

In Whole House Retrofit there is more evidence, particularly from the social housing sector, even though the number of improved properties improved is small. Wates have completed multiple refurbishments for Local authorities and the following data is from Birmingham City Council based on the retrofit of streets of low rise flats and terraces with external insulation.

A summary of costs is shown in table 4.0.5. The basis for the total costs shown is a solid external insulation system with final render, double glazing, condensing boiler, floor and loft insulation, (non-highlighted rows). Assumptions by property type are: High rise flat 25m^2 external wall, High rise flat 54m^2, Bungalow 49m^2,Mid-terrace 52m^2, Semi/end-terrace 77 m^2, Detached 110m^2

Key points from the table are that a contrast with table 4.0.4 shows a level of consistency on relative costs but the expected reduction for multiple retrofit is not obvious. Also costs for floor insulation are an order of magnitude more in the Wates multiple dwelling approach; this is for a much deeper intervention to tackle insulation under suspended flooring. Total costs, for solid wall external insulation, are between £2k and £10k higher than similar properties with cavity

wall; adding between a quarter and a half to the costs (when the 20% estimate for design, prelims, contingency and profit is added).

Table 4.0.5: Multiple Whole Dwelling Costs

Intervention	Flat High Rise	Flat Low Rise	Bungalow	Mid Terrace	End Terrace / Semi	Detatched
loft insulation new	-	£200	£200	£200	£200	£200
loft top up	-	£150	£150	£150	£150	£150
Cavity wall	£205	£205	£345	£305	£485	£645
internal wall	£1,609	£3,073	£3,320	£2,080	£3,320	£4,810
external wall	£2,271	£5,877	£4,557	£4,464	£7,756	£10,757
draught proofing	£66	£66	£66	£66	£66	£66
double glazing	£3,966	£2,211	£2,163	£3,640	£2,774	£4,218
floor insulation	-	£3,735	£5,123	£4,376	£4,376	£5,123
condensing boiler	£1,674	£1,674	£1,674	£1,674	£1,674	£1,674
Heat pump	-	-	£6,500	£8,400	£6,750	£6,750
Prelims etc. (20%)	£1,595	£2,753	£2,757	£2,884	£3,369	£4,408
Total Cost	£9,572	£16,516	£16,539	£17,303	£20,215	£26,445

The cost build-up is shown in detail in Appendix 7. Labour for solid wall insulation accounts for up to 50% of cost and is the largest single opportunity for supply chain design to reduce costs.

Pre- and Post-retrofit energy consumption data is not available for these retrofits. The Retrofit for the Future demonstration programme has this data at its core and the costs / savings are reviewed in WP 3.2. For these one off projects the material and installation costs alone will be high (typically around £70,000), but costs reduce based on repetition of the process and from multiple dwellings in the same area, as in Table 4.0.5.

5.7 Other Supply Chain Influences

5.7.1 Certification / Warranties / Guarantees

From an architectural perspective professional indemnity insurance requirements will tend to encourage designers to select products with British Board of Agrément (BBA) certification. Products are tested for performance at the component and system level against a range of criteria from thermal performance to accelerated aging. A barrier to new products adoption on a mass scale is the lag to achieve approval; this is typically two years and requires considerable investment of time product and funding. Once certified; products are more likely to be specified.

Although installation contractors will warranty their workmanship for a whole house retrofit, there is currently no warranty which gives a commitment on energy performance post works.

With user behaviour playing such an important part in the energy consumption of homes these limitations on warranties are understandable, but there is a gap in the offering if the retrofit process does not provide a mechanism for helping customers maximise the benefit of the works.

Measure by measure retrofits are covered by individual warranties and routine maintenance programmes but are function and quality not performance based.

5.7.2 Planning

Planning restricts the design solutions available to householders: External wall insulation, installation of PV and solar thermal, retrofit of windows and doors may be objected to based on the building control officers assessment of the impact on streetscape. This sets a requirement for retrofit design and supply to give a range of solutions for heritage housing types.

5.7.3 Building Regulation

The Code for Sustainable Homes has succeeded in leading a reluctant housebuilding sector to improve the energy performance of new built homes. The Code has succeeded in increasing both industry and public attention on energy performance and encouraged innovators to demonstrate the capability of new products and processes. In 2009 there was discussion about extending the Code to include refurbishment, but this has not been adopted. With the requirement for huge retrofit volumes the industry either needs to find a mechanism for robust self regulation or extension to the Building Regulations will be required.

5.7.4 Insurance

The Home Insurance market is known to be conservative to product and design innovation. For retrofit to be valued in retrofit the industry needs to demonstrate in addition to providing energy saving there is no increased, or better still there is reduced, risk of claims against insurance providers. This could prove a significant challenge with the current lack of engagement.

Insurance backed warranties exist in this market although they are not widely adopted for products and process. Potentially as a result of the variability of capability in application.

6.0 Summary of UK Supply Chain Review

The review of the current UK supply chain is to set a baseline current state from which we can identify the changes required to meet the 2050 Climate Change Commitments.

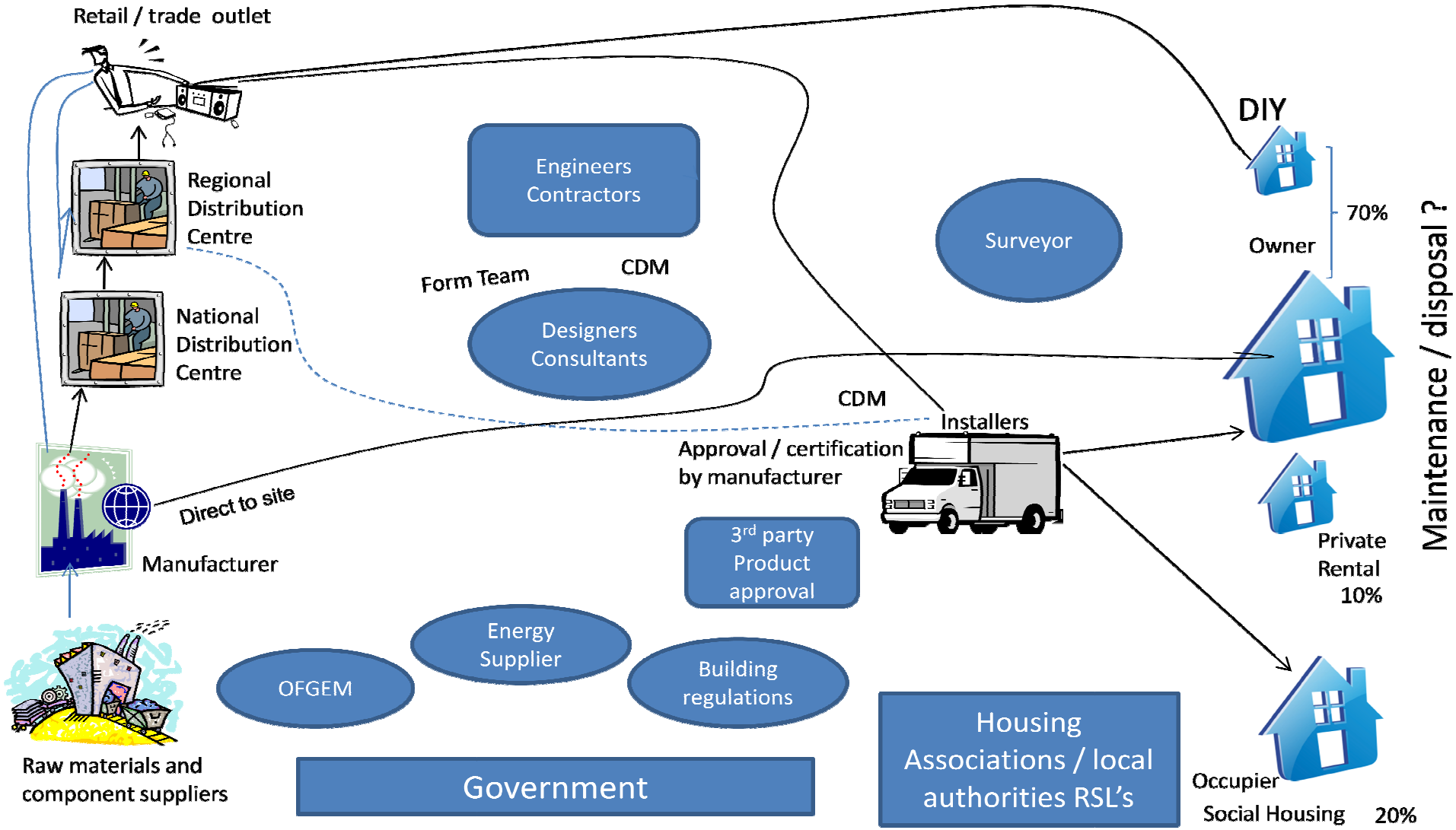
The graphics in Section 6.1 & 6.2 give visual representation of current supply chains relevant to the retrofit market. They have been developed from discussions with stakeholders.

Contrasting the two it is clear that the physical movement of materials and labour to site is straightforward (Figure 4.0.4) , but that information flows (Figure 4.0.5) add considerably to the complexity. Regulation and approval play an important role in ensuring that retrofit interventions deliver the energy savings needed, but equally the supply chain needs to find a fast and effective way to meet them. By linking the Supply Chain Design element of this project with WP6 Regulation there will be a mechanism for influencing how incentives and regulation operate most effectively.

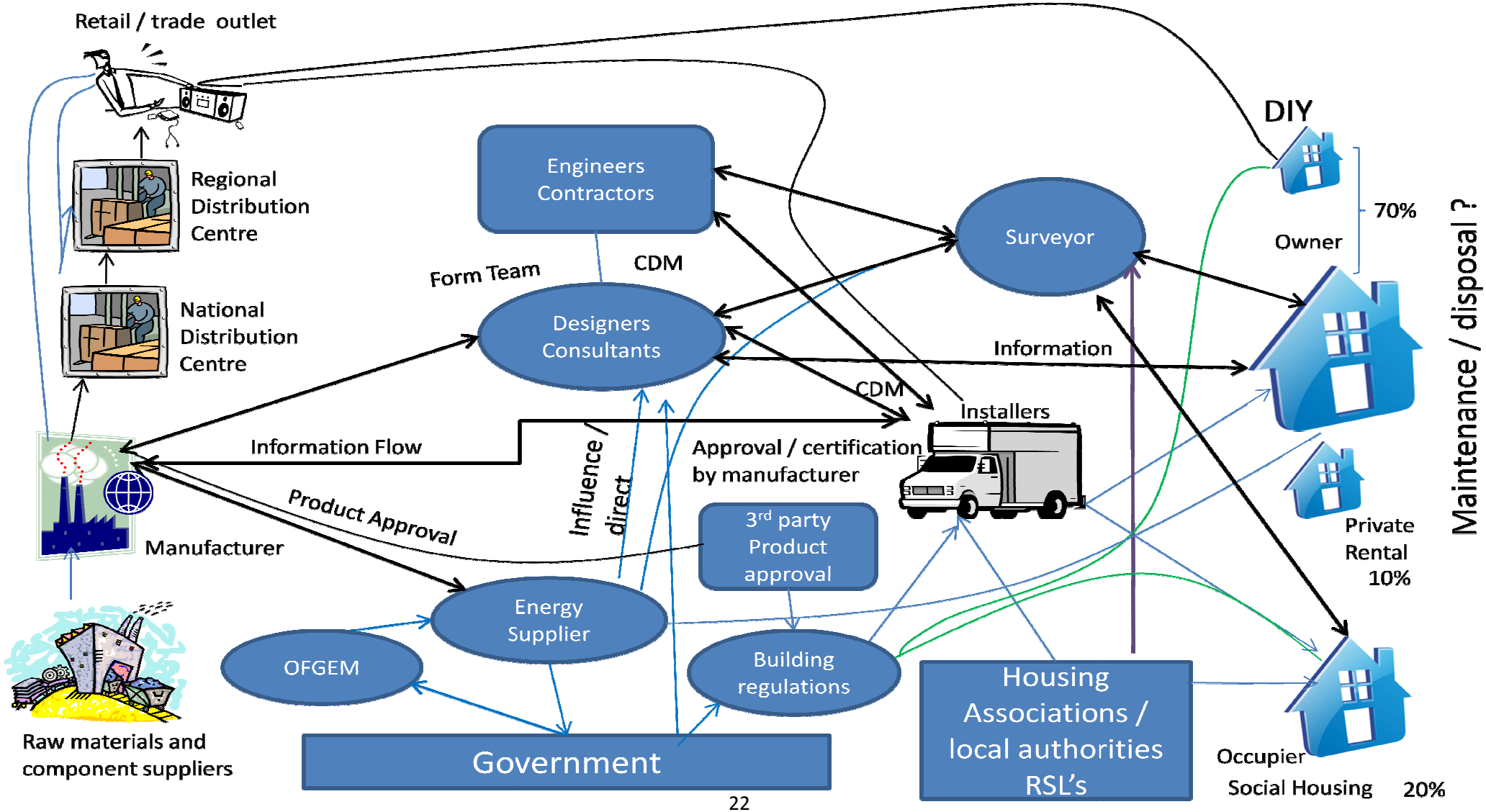
The analysis of supply chain Strengths, Weaknesses, Opportunities and Threats (SWOT) in Section 6.3 summarises the findings from across the stakeholders. The challenge for future supply chain design is to:

- Build on the Strengths
- Eliminate or mitigate Weaknesses,
- Exploit Opportunities
- Move Threats to become Opportunities

The issues deemed most critical are highlighted in bold the Table (6.3)


Retail / trade outlet
Regional Distribution Centre
National Distribution Centre
Manufacturer
Raw materials and component suppliers
Direct to site
Engineers Contractors
Form Team
CDM
Designers Consultants
Surveyor
CDM
Installers
Approval / certification by manufacturer
3rd party Product approval
Energy Supplier
OFGEM
Building regulations
Government
Housing Associations / local authorities RSL's
DIY
70%
Owner
Private Rental 10%
Occupier
Social Housing 20%
Maintenance / disposal ?

6.2 Existing Supply Chain Map Showing Material & Information Flows.



6.3 Supply Chain SWOT Analysis

	General	Sale / survey	Material supply	Installation	Maintain / disposal
Strengths	A major manufacturer of insulation products is engaged on the project	**Energy companies are mandated to promote and deliver and energy efficiency interventions.**	Manufacturers keen to improve supply logistics, look at direct to site.	**Well developed scalable national and regional product supply.**	Most insulation products do not require regular maintenance
		Home Improvement companies keen to be early adopters to secure market share	Logistics companies motivated to improve supply chain solution	**National RMI market is already developing an energy offering.**	
		Well developed scalable national and regional product supply.	**An increasing variety of products are available for use in retrofit**		
Weaknesses	**Estate agents and the housing market do not yet see a retrofitted house as having increased sales value.**	**Lack of credible sales strategies with quantifiable benefits / payback available for customers**	Manufacturers perceive the market as limited and are unmotivated to make capital investments to serve it	**Poor convenience / user friendliness and disruption, ie need to clear the attic before insulation can be installed**	Products embedded into a property will be hard to access
	Perception that each house is different and requires a unique solution	**Lack of independent advice**	**Manufacturers are waiting for guaranteed markets or incentives for retrofit.**	**Shortage of multi skilled tradespeople to do whole house retrofits**	No through life maintenance and disposal processes in place
	VAT on retrofit as opposed to no VAT on new build puts a 15% additional burden on retrofit.	**Energy use is invisible at point of use, difficult to motivate homeowners to take action**		Poor reputation of building trades to complete on time and to budget.	
		No whole house retrofit market yet – measure by measure more costly overall		Installers do not see potential in retrofit	
		Homeowners are reluctant to give strangers access into their homes: A reason people don't consider building or retrofit work.		Low tolerance in installation processes: eg. External render application in winter / Achieving required levels of airtigntness.	
		Lack of perceived value for money		**High cost of multiple staff on site: Assessors for insulation, primary heat, renewables. Multiple trades: build, joiner etc.**	
		Lack a single point of contact			

Current Supply Chain SWOT Analysis

	General	Sale / survey	Material supply	Installation	Maintain / disposal
Opportunities	**Potential for mass customisation / off site fabrication - high quality / low cost**	Whole street / community interventions could provide economies of scale	Chance to design an end to end supply chain	Real opportunity to raise skills level within UK construction	Access provision for periodic maintenance can be made easy through design
	Chance to improve public attitude to energy efficiency and take responsibility	Continuing requirement for energy companies to promote and subsidise energy efficiency measures.	Possibility to deliver whole house kits in order of use and remove waste from site on same truck	Provide multi skilled trade qualifications to improve whole house retrofit effectiveness	
	Potential to increase volume and decrease costs through the supply chain	Home Improvement companies keen to be early adopters to secure retrofit market share	Stimulation of a UK green economy for materials, products and installation processes with export potential		
	Interest from Major Retailers in becoming a trusted Home Energy Efficiency brand.	Combining with other initiatives (smart meters) could be a positive selling point.			
	Unsure how the green deal will affect this project	**The Loft Conversion / Extension market is a potential quick win.**			
Threats	The complex legislative framework and the slow rate of change caused by construction industry resistance to change.	**Lack of trust in the sales process and independence of advice given**	Insufficient supply of highest performing insulation products to supply target no of retrofits	**Inability to achieve theoretical thermal performance of solutions and energy savings in practical application.**	Risk of health issues post retrofit: Black mould growth Out-gassing from insulation. Increased Asthma
	There is no common understanding of energy performance: HIP ratings (A-G) have not made an impact	Sales routes / incentives not understood	Innovative products & materials patented and prices kept high reducing their impact.	Building control not able to respond to volume of retrofits planned	
	House typology seen as a barrier to mass retrofit	Risk of mis-match between demand and capacity (as for Warm Front)		no accreditation standard for installers - poor customer confidence	
	The availability of funding (private, householder or government) is crucial to the success of retrofit.	**Retrofit price Vs payback cannot be made attractive**		**The availability of, or resource to train, a sufficiently large work force.**	
				House by house programme of work too ineffective /costly	

7.0 French Retrofit Market and experience Via EDF Energy R&D

French House Tenure Information

Thousands of dwellings	All	Owner occupier		Social housing		Private rented	
Individual dwellings	14 794	11 950	*81%*	598	*4%*	2 246	*15%*
Flats	11 404	3 134	*27%*	3 590	*31%*	4 680	*41%*
All	26 198	15 084	*58%*	4 188	*16%*	6 926	*26%*

From the above table there are 26 million existing homes in France; similar number to the United Kingdom. The table also gives a breakdown between flats and houses, plus social housing and privately rented properties.

French Housing stock varies widely in specification and this is complicated by regional variations in building regulations

7.1 Current Retrofit Process

Energy Assessment & Sale

EDF Energy provides two levels of home energy consumption diagnostic to householders:

- Free Basic assessment based on historic energy use and house typology
- 250 Euro In depth modelling and analysis
    - Subsidy information is provided when energy saving recommendations are made
    - Diagnostic is performed by EDF Commercial division employee

Recommendations are made based on cost to install and potential energy savings

EDF energy provide advice and recommendation only.

Blue Sky energy installation partners are recommended by EDF and accredited to install. They must adhere to EDF standards and specifications.

Installation

Materials supply is via the trade, retail and direct from manufacturers

A code of excellence is in place which seeks to lead the improvement of energy efficiency in advance of regulation

Accreditations & certifications are in place for products, installers, and manufacturers.

Incentives

A variety of regional incentives are available either discounting installation or through tax credits

EDF also provide incentives through their local agencies

Weaknesses

A perceived gap in the service provided is a project engineer to oversee installation and coordinate the different trades on site

France lacks a control procedure for the whole supply chain (from audit/diagnosis to installation).

7.2 Progress to Date

Current take up of retrofit consists of

- 70% Thermal improvement mostly insulation and double glazing
- 30% heating systems

Actual numbers of interventions which have been funded and completed are proving difficult to establish.

Exemplar projects have achieved 89% reduction in space heating costs but at a high cost. More typical results are of 53% reduction in space heating costs. (Calculated not measures reductions)

Householder motivation for retrofit is an existing need for building work (repairs or extension). Subsidies are used to improve the quality / energy efficiency of these works.

The energy efficiency certificate issued on completion of works is seen as a motivating factor, but the environmental benefits are not.

Obstacles

Negative impacts cited by householders are: disruption, noise, dust, damage and loss of power. To mitigate these there is a preference to use on site project managers to manage the works.

Supplier Motivation

EDF prioritise energy saving in regions with an identified weakness in grid capacity.

Outstanding questions.

- Number of retrofits carried out, what work is done, cost and time taken
- How skills are managed ?
- Planed vs Achieved energy savings

Data for the above is not currently available. The availability of this will be reviewed as the programme progresses and will be published when possible.

8.0 German Retrofit Market

The German Retrofit Market is the most established and mature of the nations studied with 6 years of regulated retrofit.

In Germany there are 40.2 Million households (DESTATIS Federal Statistical Office) 55% above UK.

A law for saving energy in new buildings was established in 1984, all buildings built later are deemed to be of a decent energy standard and the Government does not fund assessment or refurbishment of these buildings. These buildings account for over 14% of the building stock in Germany

8.1 Objectives

Performance: 90% reduction in **heating** energy demand. From average of 220kWh/m^2/yr. Target: 22kWh/m^2/yr (Very hard to achieve in retrofit of older properties) 60% reduction is more realistic for older properties giving 80kWh/m^2/yr.

Target Rate: 2% per annum (40yr cycle with recent newbuild and completed projects). Actual rate: 0.3% per annum.

Target Cost: €75,000 per dwelling; government funded to 17.5%

Target Time: 18month enquiry to completion of whole house retrofit.

8.2 Current Retrofit Process

Energy Assessment & Sale

Retrofit assessment is carried out by trained and certified energy consultants who assess the optimum solution and savings for each property. Typically consultants are engineers or architects; although there is a route for independent trades-people to become certified.

Training towards certification takes 6 weeks full time study or 6 months part time. The tradesperson route takes 1 year part time study. Certification is subject to passing a set exam.

In 2007 there were over 6000 registered certified energy consultants listed, numbers are increasing and not all energy consultants are listed.

Access to the market is via free trade / certified consultants / installers.

Consultants, architects / engineers use software modelling to assess what measures are appropriate, and work out what government funding is available. The models used by German energy consultants are the EnEV and sometimes the PHPP (these have been reviewed in WP 1.1)

There are several computer tools available to assess the buildings in their current state and then make proposals for variants and calculate energy savings, emissions, payback times and costs.

Consultants make recommendations to householders based on cost to install and potential energy savings and offer to apply for funding on their behalf (almost always accepted).

These consultants are fully independent the single point of contact for the funding.

Accredited contractors are selected by the consultant who builds a local network or trusted suppliers.

Installation

Only whole house retrofits are considered

DIY installation and discontinuous works are no longer funded

Consultants oversee the installation works and inspect / certify the result

Work is carried out by qualified trades-people

Distribution of materials etc. is via a wholesale distribution model

Incentives

The surveys of pre 1984 buildings are funded up to half of the actual costs by the Government. Costs for these surveys start at about 600 € for a typical family home.

Government provides funding at up to 17.5% of works and low interest loans for carrying out retrofit works.

Weaknesses

Insufficient understanding from householders of the sale of the works and changes in advance of the work: Better pre-installation communication is required.

Not enough dissemination of best practice examples to engage a broader population.

Market growth is insufficient to meet the target rate and completion date.

8.3 Progress to Date

year	2006	2006	2007	2007	2008	2008	2009	2009
	Houses	Total Dwelling units	Houses	Total Dwelling units	Houses	Total Dwelling units	Houses	Total Dwelling units
Whole house solutions	42.549	147.797	20.837	83.559	28.624	122.016	30.199	132.700
Single actions eg: insulation	51.021	123.045	26.689	62.740	43.306	91.760	59.082	152.815 now ended
Grant: for whole house or single actions	-	-	2.791	4.922	7.664	12.241	114.714	262.027

For 2010 year to date (1.1. - 30.09. 2010)

- Whole House: 101,000 dwellings in 17,000 buildings
- Single actions: 130,000 dwellings in 40,000 buildings

The single actions programs have finished completely in Sept. 2010, now only whole house solutions are being funded.

Estimates for people employed in retrofit actions are 292,000 in 2010 with the programme of government funding.

9.0 Contrasting French, German and UK retrofit Markets

9.1 Energy Assessment & Sales

The German model is seen to have major benefits in using the energy consultant as a focal point in the retrofit process from initial enquiry, through grant application to completion. They recommend certified installers and products and locate available funding for the works. As an independent the consultant is also seen as best placed to give impartial advice.

The French 'Blue Skies' companies are not seen as fully impartial or accountable for the resulting energy performance. The French Market is moving towards the German model as the need to have a trusted and professional focal point for planning and managing the retrofit is seen as key to achieving customer acceptance. This needs to be contrasted with the cost of a highly trained professional to see the project through to completion.

The UK market tends to be sceptical of purely commercial contacts brokered by the Energy Companies. The single point of contact is attractive, but householder experience of assessors for Home Information Packs does not fill them with confidence.

9.2 Installation

Germany has decided to cease funding of single measures; having recognised that these are unlikely to achieve the seep cuts in consumption required. Despite the higher cost of whole house solutions; the total cost is lower than multiple single measure interventions.

Installers in France are generally approved by power companies to supply retrofit products.

Installers, materials and trades people in Germany are certified to national standards although this is not enforced as rigorously as in France.

There persists an impression that UK trades people are disinterested in investing to become qualified in their chosen trade as with the German approach. This lack of technical (and customer service) capability plays a part in the continuing reluctance for homeowners to allow people into their homes to carry out building work.

Potential UK installers are considering gearing up capacity but are unconvinced that the market will take off without government stimulus.

Germany has an expectation of €75,000 per property with 17.5% government funded: Equivalent to £67,000 funded to £12,000.

UK Green Deal loan expected around £6,000 and consumers do not anticipate spending more.

9.3 Incentives

None of the nations reviewed have generated a programme on a true mass scale.

Although the German market is seen as the benchmark for technical performance the whole house retrofit rate is only running at 0.3% of the stock per year and growth is modest. At the single action level German volumes are considerably below those currently achieved in the UK.

Despite the lack of hard data from France the estimated refurbishment rate is also lower than the UK. The financial incentives are seen as inadequate to encourage the mass market to undertake work unless already planned for repair or extension.

The UK CERT programme has been a major stimulus to intervention and take-up and the extension to ECO in 2012 and beyond will be a major factor in increasing momentum.

The UK's Feed In Tariffs for PV and the Renewable Heat Incentive have generated considerable interest with their generous guaranteed financial returns. This has stimulated a whole new market, arguably focusing on the less cost effective measures, but also risks homeowners postponing a potential decision to invest in retrofit until subsidies are available.

In Germany the subsidy available for retrofit work is capped at 17.5% of total cost of whole house projects. In addition there are regional funding options, but in total these are not enough to persuade building owners to embark on retrofit unless repair or expansion is already planned.

Local subsidies are in place in France, these vary by region, including special incentives in areas where grid capacity is under pressure.

The UK Green Deal is an initiative which is intended to give additional boost to energy saving measures. A loan linked to the property will be made available to all which is repaid on a Pay As You Save basis. Estimations of the level of loan available range from £2,000-£10,000 with £6,000 seen as a likely level. Contrasting with the German costs of €75,000 per household; shows that,

if figures are correct, the Green Deal is unlikely to be enough of a stimulus to whole house retrofit on its own.

9.4 Fires In Buildings With Photo Voltaic Panels

In Germany there is no official policy on firefighting of properties with PV installations. However:

- There was one recorded instance of fire fighter badly injured.
- In case of doubt the fire brigades would rather let a roof burn (controlled) than risk lives
- Various producers of PV are developing technical solutions to short-circuit panels in case of emergency.
- The fire brigade of Munich has developed a special foam to cover PVs completely

In France there have been problems with firefighters refusing to deal with fires in properties fitted with solar PV panels since these could be tied to the grid. There is no documented data of injury or fatalities.

There is anecdotal evidence from the US of concerns regarding fire fighting fire involving PVs. It is said told that some firefighters have been killed by electrocution while attempting to vent fires through PV roofs. As yet research has not found any proper reports of these incidents.

10.0 Conclusions & Next Steps

10.1 Key Issues

From the previous analysis the supply chain challenges to generating a mass scale retrofit are summarised under the seven categories of: Demand, Payback, Design, Survey, Material, Installation, Regulation.

10.1.1 Demand / Sales

There is currently no significant market for whole house retrofit, despite a broad interest in energy saving and renewable energy. The message that a whole house solutions will perform better than individual measures has not be adequately communicated.

Lack of consistent information and single point of contact for advice and information are seen as blockers to the whole house approach.

A general lack of trust in building trades' ability to deliver to promise leads to consumers delaying decisions to undertake work until installers are recommended by trusted sources and their work can be seen first hand.

Retrofit needs to avoid a 'cowboy' phase and move straight to sophisticated value propositions.

10.1.2 Performance & Payback

Even the energy saving community has not yet aligned itself behind a common set of measures. Many initiatives quote % energy saving or a £ bill saving. Both of which have severe limitations. The Energy Zone Consortium will work with Stakeholders to agree a common and easily communicable set of measures.

Direct payback can only judged on reductions in domestic energy bills. With the current average fuel bill of £1200/yr the return is finite and the level of retrofit investment needs to be minimised to make payback attractive.

10.1.3 Design

There are currently insufficient design solutions to tackle the diversity of UK housing types.

Key issues are:

- Solid wall solutions
- Heritage and planning restrictions
- Partial retrofit low hanging fruit: Loft conversions extensions – energy comes free.

With each property considered as unique (particularly in the private sector) the cost burden of design and planning is currently disproportionately high.

10.1.4 Survey & Assessment

The German Energy assessor is seen as a trusted source of impartial technical advice, but the cost burden and time to train is high.

Home surveys need to assess multiple factors (including existing fabric and electrical condition) to ensure measures are not installed on top of defective building elements; shortening their useful life.

To minimise cost and multiple home visits survey and sales should ideally be combined.

10.1.5 Material Supply

There is an opportunity to reduce significantly the cost of new products by stimulating demand, and encouraging competition.

Lead time to increase manufacturing output of insulation products is said to be 12-24 months.

Need higher performing super-insulations for niche applications (dormer windows, solid wall)

With the Window Energy Rating system the window industry has migrated towards A rated products, but this needs to be accelerated, enhanced to A++ and broadened to include doors.

Need to develop solutions for ‘post-gas’ boilers if the strategy is to move away from fossil fuels.

10.1.6 Installation Process

Limited availability of skilled trades people limit current capacity to retrofit homes: How can we standardise retrofit tasks to become simple to train and quality assure?

Disruption to the householder makes the whole house retrofit approach a challenge to sell.

Avoiding multiple tradespeople on site will make the installation process more attractive.

To ensure a quality offering; retrofit will need to be profitable to attract professional installers.

10.1.7 Regulation

Feed In Tariffs (FIT) have stimulated demand for renewable technologies. This shows what can be done albeit at a high cost; there is a risk is all new offerings will expect a high level of incentive.

Mandating improved energy performance as part of planning approvals for home improvement would create demand, but the cost will need to be marginal to avoid strong public opposition.

10.2 Performance Measures

The objective of providing a framework of metrics is to assess how capable the supply chain is to deliver the mass retrofit programme.

From the data and views collected in the previous sections an assessment of supply chain capability can made against the following:

10.2.1 Performance:

Ability of the supply chain to contribute to significant reductions in national energy consumption.

As discussed above there is no universally energy efficiency measure for domestic properties. The Consortium aims to build consensus with stakeholders. Current preferred measures:

- Energy Consumption: kWh/m2/yr
  - \+ Direct link to energy bill, quantifiable savings, comparable with Passiv Haus standards.
  - – Fuel poor homes appear to perform well, does not account for occupancy or climate.
- Heal Loss Rate: W/K
  The rate at which energy is lost per degree of temperature difference internal to external
  - \+ Direct link building fabric thermal performance. Excludes appliance and user behaviour.
  - – Difficult to measure directly, or to link to energy bills.

10.2.2 Capability

Working with the WP5 work on Customer Value the Supply Chain group will develop a detailed specification for householder requirements for the following criteria:

- Quality – Has the intervention met expectations of quality of service and finished work
- Speed – Is the time taken for each stage of the process (survey, quotation, installation, service) considered reasonable by the market.
- Flexibility – Are the measures flexible enough to meet clients changing requirements (household occupancy, climate change, redecoration and home improvement)
- Reliability – Was the service provided, on time as planned and did it perform as expected through life.

10.2.3 Volume

Capacity to deliver at scale enabling full retrofit of 26M UK homes by 2050

Measured as the current % of flat run rate required to complete all homes by 2050.

Actual annual capacity / Target Annual Number of properties to be retrofitted X100

This must cover:

- Assessment of property
- Design of solution
- Material supply to embody the solution (manufacture and delivery)
- Labour supply with the required skills to embody the solution
- Regulatory approval of the design and embodiment of the solution

10.2.4 Regional Coverage

As the industry scales up there may be regional variations in capacity and by housing type. By linking with the Housing Stock Model from WP2 a traffic light system will be used by region to indicate capacity.

10.2.5 Investment criteria

For the market and its supply chains to thrive a measure of Affordability and Payback is required: On what basis would the householder / owner make the necessary investment in energy saving? This measure will need to take into account cost of interventions, energy price, cost of capital (eg: via Green Deal), subsidies and incentives.

Using the Green Deal Golden rule of payback the Consortium will test the viability of:

$$Payback\ (yrs) = \frac{Cost\ of\ Intervention}{Annual\ Energy\ Bill \times \%\ Saving - Cost\ of\ Intervention \times Cost\ of\ Capital\ \%}$$

Crucially it needs to be noted that this simple payback equation is quite likely to give a negative result. This is best demonstrated by a realistic example:

- Whole House Retrofit: cost £10,000
- Current Energy Bill: £1,200,
- Cost of capital 5%
- Estimated savings 30% (50% saving on space heating and domestic hot water).

Here the annual cost of servicing the debt is £500 and annual saving only £360: so there is no payback. The options to shift the equation are:

- Drive down the cost of investment (by subsidy or industrialisation of supply)
- Improve the energy saving of the interventions (diminishing returns above 50%)
- Allow energy prices to increase, or increase taxation of energy.
- Reduce the cost of capital by guaranteeing payback.

With current levels of Energy Poverty running at 16% (DECC 2007) energy Affordability is already an issue for one household in seven, of which the majority (78%) are considered vulnerable (elderly, with young children, disabled). This prioritise improvements on the retrofit supply side.

The funding and economics is crucial to the project and is a key focus at the Project or Systems level, with research into consumer value through Work Package 5.

10.3 Feedback From Key Stakeholders

Between the draft and this final version of the report the team collected feedback on content and conclusions from major stakeholders. This acted as a peer review process which flagged up additional aspects which have been incorporated above as well as further reinforcement of the view that there is a consensus on the priority of stimulating demand, but no consensus on how to achieve it.

The following organisations provided a peer review of this report.

- Department for Energy and Climate Change (DECC)
- Construction Products Association (CPA)
- Energy Saving Trust (EST)

- Energy Technology Institute (ETI)

The Department for Business Innovation and Skills (DBIS) and the Carbon Trust have also been approached, but have not yet provided feedback.

10.3.1 Feedback from DECC

The report covers the basic parts what exists in the supply chain for whole house retrofit for energy efficiency. The green deal will introduce a method for funding retrofit works and it is important that this is kept in mind when developing solutions and a supply chain to deliver them. Modelling of proposed retrofit works will be interesting and we are interested in seeing illustrations of more than one occupancy model when summarising benefits of the retrofit.

Forthcoming work should cover :

- How uptake of retrofit is maximised
- How the retrofit can be industrialised and not just rely upon a mass market to drive down costs
- How regulation and secondary legislation can be used to :
  - Set principles of acceptance on measures
  - Introduce competition
  - Encourage and Allow local suppliers to enter the game
  - Maximise Value for the householder and look at how this is passed on.

10.3.2 Feedback from CPA

There are some assumptions in the original report that we find curious.

- Insurance backed warranties do exist in this market, they may not be applied simply but they do exist.
- Getting waste from site diverted from landfill is important and our members have the objective of halving this by 2012.

Home Insurers attitude to retrofit may throw up some interesting challenges; they don't like anything out of the norm.

CPA members see the retrofit market as huge and many are making this their core business

Material and component supply is unlikely to be a problem; the industry has a lot of spare capacity now. As long as demand does not arrive "overnight" supply will be there.

To make retrofit a more acceptable proposition; would it be more effective to compete this either room by room, or measure by measure?

The key challenge is to make retrofit affordable.

Street by street initiatives unlikely as we can't even get a street of people to take free insulation.

Need to consider how the competent person scheme could operate to avoid overloading building control.

The building trade has significant spare capacity since the down turn and a programme such as this provides a significant opportunity to use it. Many players already see retrofit as their core business.

Need to come up with a way to pass on the "value" of the retrofit between owners / occupiers.

10.3.3 Feedback From The Energy Saving Trust

Engaging Householders

Recent “trigger points” research shows that for many householders they take action on energy efficiency as they are undertaking other room-by-room refurbishment projects.

Research did not cover whole street refurbishment, but it is unlikely that a private householder would ever consider this as a potential option.

EST test people's "trust" in organisation types on a quarterly basis to assess who they value for energy advice. Friends, family and Which? Consistently perform best; with concerns that commercial organisations may have mixed motives (this includes retailers, energy companies and supermarkets.

Supply Chain Capability

EST work has focused on the general builder as ~80% of all refurbishment work is done by this sector. The general feeling from this audience is that they know all about "green refurbishment" However when challenged about what an Energy Performance Certificate (EPC) is knowledge is patchy at best. With only 61% having heard of an EPC and the majority not understanding the implications for the homeowner. A qualitative view is that capability in this sector is very weak.

EST’s manta is "insulate, A-rate, generate". Of primary importance would be appropriate insulation measures (including glazing) and a drive to increase airtightness. Improving heating systems through boiler upgrades, individual heating controls should be considered as a priority as should lighting.

Measures such as MVHR (mechanically ventilated heat-recovery), the gas-saver system and other products that increase energy efficiency should be considered when priority measures have been completed, but before adding on micro-generation technology.

The Role of Regulation

Home Information Packs (HIPs) failed to become part of the housholders decision making process. EPCs should be the key tool for engaging consumers as has been successfully demonstrated with white goods. However many consumers believe that EPCs were a requirement under HIPs (which have been scrapped) and therefore are no longer a necessity.

With the internet price of EPCs having fallen to £30+VAT, Domestic Energy Advisors must be struggling to both make money and to deliver a quality service.

We suggest robust quality accreditation and training schemes – to turn EPCs and future Green Deal assessments into a product that is valued by householders and the housing industry.

EPCs should become the key information tool for people considering taking action around home energy efficiency and low carbon refurbishment and need to become a common currency for householders and the housing and refurbishment industry.

10.3.4 Feedback From The Energy Technologies Institute

Overall the report pulls together a good picture of the retrofit supply chain applicable to the UK.

One aspect of the supply chain that needs to be considered as part of the project is the capability to actually reduce energy, not just throughput. This should be addressed at some point in the supply chain work. (Strong links with WP1 & 3 in Milestones 3 & 4 – see 10.3 Measures)

The acceptance criteria highlight that the results will be shared with other stakeholders and reactions documented via either focus workshop or face to face meeting as appropriate. These have now been completed other than:

- Carbon Trust – Substituted contacts with Energy Saving Trust above.
- Department for Business, Innovation & Skills – DBIS Not complete see below.

Existing supply chain commentary

Was originally a series of bullet points. What are the implications of these statements and what challenges / opportunities do they present?

Existing Supply Chain SWOT analysis

- Is the availability of a sufficiently large work force a Threat? - *Added to matrix.*
- Funding for retrofit must be a threat under the General category – *Added to matrix.*
- French system incentives are mentioned a couple of times, where are these documented? Have they been provided to the WP5 & WP6 team? – *French* market *Incentives appear to be highly regional and often short term, also, as covered in 7.2 even with EDF as a partner getting access to numerical data is difficult. Other workpackages will be updated in line with 4.1 timings.*

Timings needed for outstanding questions

- Contrast of the UK supply chain with Scandinavia – No contacts identified / forthcoming during the first 7 months of the project. - *To be updated in line with 4.1*
- Department for Business, Innovation & Skills – DBIS – Now working via TSB who have a direct interest. - *To be updated in line with 4.1*

10.4 Review and Next Steps

A crucial learning point from this stage of the project has been the step change in the level of engagement when the focus changes from passive 'interviews' to active workshops. There was a much greater level of response and contribution once organisations attended the initial supply chain design workshop. An early engagement workshop would have greatly assisted the team in gathering the existing supply chain data earlier and raised the quality of the output to the level above in the first rather than the delayed revised version.

There are still three gaps in data this review which will be addressed in line with Deliverable 4.1 – Initial Supply Chain Design:

- Information on retrofit activity in Scandinavia – contacts now established.
- Feedback from DBIS – via TSB and Construction Support Unit.
- Further numerical data from the French market of costs, incentives and volumes.

There are two challenges coming from the research information:

- The conflicting views from supply chain partners: Whether there will be a future retrofit market or if the idea of energy efficient homes is ignored long enough it will go away.
- There is a complacency from manufacturers and installers that they have the capability to respond to a new market within 12months. There is no evidence that they have yet understood consumer requirements or are willing to invest in new value propositions to serve them.

To validate some of the statements and views from interviews; the WP4 team will look at live retrofit works to test the opinions and gain further insight into supply chain activity. This forms part of the Supply Chain Design phase in deliverables 4.1 (initial design) and 4.2 (supply chain scenarios).

The Supply Chain Workshops have generated interest and valuable contributions from a core of potential supplier organisations and the challenge is to ensure this built upon, while avoiding the potential charge that the contribution organisations are an exclusive and un-representative group.

Three of the challenges to seen as crucial to success at this point are:

- Develop a multi-skill site approach which enables seamless, cost-effective site work with minimal disruption to householders; instead of a series of trade based activities.
- Develop factory prepared kits, ready to fit, with short leadtimes; which speed up installation, minimise disruption and give assured quality performance.
- Generate supply solutions that treat retrofit as a System solution instead of a series of bolt on interventions. With product and service providers acting together there will be more potential to improve overall thermal performance, reduce cost and minimise householder disruption.

Existing Supply Chain Appendices.

Appendix 1: Stakeholders: *Considered* /Contacted **/ Most Useful**

- Householders
- **Architects**
- Designers / engineers
- Specifiers (M+E)
- **Installers**
- Final customers
- **Trades people**
- Building officers / regulation / control
- *Financiers - did not find time to engage*
- Stockists
- **Distributors**
- **Logistics and delivery companies**
- Communities
- **Housing associations**
- **Trade bodies**
- *Scaffolding and access systems companies*
- Waste management companies
- **Manufacturers – products , systems, components and raw materials**
- *Product developers – Only as part of manufacturing organisations*
- **Construction materials buyers**
- *Unions*
- Training providers
- Energy providers
- **Utility Companies**
- *Insurers- did not find time to engage*
- Local Authorities
- *On site catering*
- *Plant hire companies*

Appendix 2: Sources of Information for products, services and potential solutions.

- Trade bodies:

  Construction Products Association, Link to the CPA Low Carbon Domestic Refurbishment Guide: http://www.constructionproducts.org.uk/publications/Page.aspx?Id=511
- Independent traders / outlets
- Distributors
- Trade catalogues
- Trade and professional associations
- Universities and colleges
- Manufacturers
- Web
- Local authorities
- Installers
- Trade shows (ecobuild etc)
- Client
- Designers
- Architects
- OFGEM
- Certification bodies
- BRE
- Construction Products Association
- Energy Saving Trust
- Energy Providers

Appendix 3: Participating Companies

- Companies approached / participating in the development of the current supply chain map include: (Number of ticks indicate the level of involvement / engagement)
  - PRP Architects ✓✓✓
  - Wates ✓✓✓
  - BASF (multiple divisions) ✓✓✓
  - Travis Perkins ✓✓
  - Peabody ✓✓✓
  - EDF Energy UK and France (R&D) ✓✓✓
  - BRE ✓✓✓
  - DHL ✓✓
  - Green Building Council ✓
  - Carbon Trust ✓
  - ETI ✓✓
  - Construction Products Association ✓✓✓
  - Anglian ✓✓✓
  - Sheffield Insulation Group ✓✓
  - Isothane ✓✓
  - Construction Skills Council ✓✓
  - Council of Mortgage Lenders
  - Association of British Insurers
  - Energy Saving trust ✓✓
  - Sustainable Energy Academy ✓✓
  - The Mark Group ✓✓

Appendix 4: Materials for retrofit

	Supply				Performance					Environmental						
Product	Variety	Volume	Cost	Route to market	Thermal Perf	Water Tolerance	Air tightness	Fire retardancy	Guaranteed life	Recyclable	Dust / contaminati on	Chemical resistance	Ease of installation	Handling	Storage	disposal
SUDG Windows	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	
A* Rated SUDG Windows	✔	✔	✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	
Doors	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	
Cellulose fibre	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔	✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	
Glass Wool Fibre	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔	✔ ✔	✔ ✔	✔	✔ ✔	
Rock Wool Fibre	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	
Expanded polystyrene	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔	✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	
Extruded Polystyrene foam	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔	✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	
Polyurethane Foam with CO2	✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	
Polyurethane Foam with Pentane	✔ ✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	
Phenolic foam	✔	✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	
Polyisocyanurate foam	✔	✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	
Phenolic foam with foil	✔	✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	
Polyisocyanurate foam with foil	✔	✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	
Aerogel Blanket	✔	✔	✔	✔	✔ ✔ ✔	✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔	✔	✔ ✔	✔	✔ ✔ ✔	✔ ✔	
Vacuum Insulation	✔	✔	✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔	
A rated Condensing Gas Boiler	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	NA	NA		✔ ✔ ✔	✔	✔ ✔	NA	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	
Solar thermal	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	NA	NA		✔ ✔ ✔	✔	✔ ✔	NA	✔ ✔	✔ ✔	✔ ✔ ✔	
Heat Pump	✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	NA	NA		✔ ✔ ✔	✔ ✔	✔ ✔	NA	✔ ✔	✔ ✔	✔ ✔ ✔	

Appendix 5: Installation Capacity Assumptions

Definitive solid wall retrofit volume data has proven hard to establish – even with a report directly commissioned by the EST (see reference below).

- The installations of External Solid Wall Insulation given in section 5.4.1 are the EEPH report's best estimates based on (a) CERT data (b) specialist installer capacity. The range (a)50,000 to (b)10,000 /year and so the estimate of 13,000 has significant uncertainty.
- For Internal Solid Wall Installation the uncertainty is compounded by the number of non-specialist installers and the range of solutions from: Reflective wallpaper to 300mm of internal phenolic insulation. The figure of 7,000 should therefore be taken as an 'order of magnitude' indication rather than an exact figure.

Source: *UK Solid wall Insulation Sector Profile* (May 2009) produced for the Energy Efficiency Partnership for Homes: http://www.eeph.org.uk/uploads/documents/partnership/SWI%20supply%20chain%20review%208%20May%2020091.pdf

In the 18months since this report was published the Solid Wall market will have moved forward, but with a capacity requirement of 150,000/yr to achieve all 6M solid wall properties by 2050, Solid Wall Insulation installers and Trade Bodies will form an important part of the supply chain design process.

Appendix 6: Waste

- Hippowaste Wates: Using the data above we can calculate the percentage of waste, by weight, diverted from landfill as:
- 120kg/4260kg = 2.82% to landfill = **97.18% diverted from landfill.**
- The material classified as landfill can be described as items deemed not able to be processed any further.
- **Carpet** – This material requires a specialised recycling process and due to the small quantities involved is not commercially viable to so.
- **Linoleum** – If not classed as hazardous and removed by an accredited company, this material requires a specialised recycling process and due to the small quantities involved is not commercially viable to so.
- **Carpet tiles** - This material requires a specialised recycling process and due to the small quantities involved is not commercially viable to so
- **Contaminated waste** – Small amounts of waste, that are contaminated by other materials.
- **Polystyrene** – There is no commercially viable process available for this waste stream, therefore it will go direct to landfill
- Disposal at end of useful life is not generally considered, this must be considered when designing the whole house retrofit solutions.

Appendix 7: Table of Quantities required for whole house retrofit - materials and labour

	Labour hrs	Labour Cost £	Material £	Material Qty	Total £	Labour hrs	Labour Cost £	Material £	Material Qty	Total £
	Flat High Rise: 25m^2 External Insulation					Flat Low Rise: 54m^2 External Insulation				
loft insulation new	-	-	-	-	-	2.8	55	145	41	200
loft top up	-	-	-	-	-	2.8	55	95	41	150
Cavity wall	4.0	100	105	21	205	4.0	100	105	21	205
Internal wall	64.0	1,184	425	21	1,609	106.0	2,000	1,073	53	3,073
external wall	62.0	1,145	1,126	21	2,271	163.0	3,015	2,862	53	5,877
Draught proofing	1.5	28	38		66	1.5	28	38		66
double glazing	42.0	772	3,194	1	3,966	28.0	450	1,761	1	2,211
floor insulation					-	180.0	2,840	896	35	3,735
condensing boiler	43.0	953	721		1,674	43.0	953	721		1,674
Heat pump					N/A					N/A
Prelims etc. (20%)					1,595					2,753
Total Cost	Unshaded interventions only				9,572	Unshaded interventions only				16,516
	Mid Terrace: 52m^2 External Insulation					End Terrace / Semi: 77m^2 External Insulation				
loft insulation new	2.8	55	145		200	2.8	55	145		200
loft top up	2.8	55	95	41	150	2.8	55	95		150
Cavity wall	4.0	100	205	41	305	4.0	100	385		485
Internal wall	68.0	1,250	830	41	2,080	106.0	2,000	1,320	19	3,320
external wall	122.0	2,250	2,214	41	4,464	194.0	3,593	4,163	77	7,756
Draught proofing	1.5	28	38	1	66	1.5	28	38		66
double glazing	28.0	450	3,190	1	3,640	28.0	450	2,324		2,774
floor insulation	180.0	3,326	1,049	41	4,376	180.0	3,326	1,049	41	4,376
condensing boiler	43.0	953	721	1	1,674	43.0	953	721		1,674
Heat pump	32.0	800	7,600	1	8,400	32.0	800	5,950		6,750
Prelims etc. (20%)					2,884					3,369
Total Cost	Unshaded interventions only				17,303	Unshaded interventions only				20,215
	Bungalow: 49m^2 External Insulation					Detached: 110m^2 External Insulation				
loft insulation new	2.8	55	145		200	2.8	55	145		200
loft top up	2.8	55	95	41	150	2.8	55	95		150
Cavity wall	4.0	100	245	49	345	4.0	100	545		645
internal wall	106.0	2,000	1,320	49	3,320	150.0	2,830	1,980		4,810
external wall	104.0	1,933	2,624	49	4,557	263.0	4,866	5,891	109	10,757
draught proofing	1.5	28	38	1	66	1.5	28	38		66
double glazing	28.0	450	1,713	1	2,163	28.0	450	3,768		4,218
floor insulation	215.0	3,894	1,228	48	5,123	210.0	3,894	1,228	48	5,123
condensing boiler	43.0	953	721	1	1,674	43.0	953	721		1,674
Heat pump	32.0	800	5,700	1	6,500	32.0	800	5,950		6,750
Prelims etc. (20%)					2,757					4,408
Total Cost	Unshaded interventions only				16,539	Unshaded interventions only				26,445

The figures above are actual quantities from live projects carried out over the last 12 months (2009-10)

Air source heat pumps are not used in flats due to the difficulty in finding sites for external units.