Programme Area: Buildings

Project: Building Supply Chain for Mass Refurbishment of Houses

Title: Target supply chain scenarios

Abstract:

Please note this report was produced in 2011/2012 and its contents may be out of date. This deliverable is number 4 of 8 in Work Package 4. The report builds on prior work in Work Package 4 together with taking inputs from WP3.4b (Single Dwelling Implementation Plan) and WP5.4 (Consumer Engagement) to test out 5 models of supply chain design against the requirements of consumer segments with whom a successful retrofit engagement is most likely. On site approaches to deliver the basic and enhance retrofit packages designed in WP3.4b are presented with the conclusion that most can be delivered in 3 – 5 days stretching to 7 days for the most complicated. The report proposes that a national franchise model for retrofit is the most appropriate for the successful up-take of mass retrofit.

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.

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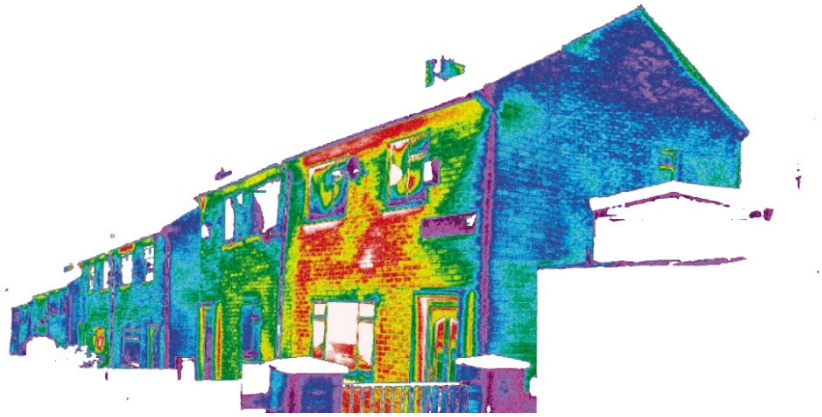

Optimising Thermal Efficiency of Existing Housing

Document:

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Target Supply Chain Scenarios

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Contents

1 Executive Summary

This work package deliverable builds on the previous retrofit Supply Chain Scenarios report (WP4.2) taking inputs from the current Consumer Research (WP5.4) and Single Dwelling Refurbishment Plan (WP 3.4b); testing that the value propositions developed meet the needs of the customer groups and are achievable in practice.

In addition, five models of supply chain design previously suggested are reviewed and tested against customer requirements, existing supply chains and investment motivation. In the absence of a current market we examine which systems should be in place to give customers, suppliers, investors and government confidence that retrofit will deliver value for money. It is revealed that no one model is suitable across all segments, tenure and house type and a range of delivery options is desirable

The survey process has been studied in detail and the target of a single visit survey has been challenged. We now propose a 2 stage process which minimises exposure to the expense of carrying out an in depth invasive survey before a commercial agreement is in place with a potential customer. This reduces the risk of minor damage as a result of the survey and the possibility that appliances of gas and electrical supplies could be condemned during the process. Manpower and the predicted time taken are far in excess of what is desirable and this needs further study to deliver a step change in performance.

The strategy for retrofit installation is the elimination of current trade based supply chain delivery approaches and reduce the delivery team to 5 multi-skilled retrofitters. This has been successfully demonstrated in theory for the basic retrofit packages specified by WP3.4b across 8 house types. The retrofit programmes presented within this report are delivered within 7 working days for the most difficult properties and typically 3-5 days. Delivering retrofit in shorter time will help to reduce cost; the prime driver for customer acceptance of whole house retrofit. This is a leap from current delivery performance and will require multi skilled retrofit teams with exacting programming, sequenced material deliveries to site and effective waste backhauling. New systems of training and accreditation will be required to support the growth of the retrofit market and ensure high levels of customer confidence.

The clear message received from work in WP5.4 is that Cost will be the key driver in customers' decision to take up retrofit; ahead of disruption and speed. To reduce the up-front cost new ownership models for products such as primary heat source (heat pumps, boilers etc.) could be provided under a lease / maintenance contract.

The scalable delivery unit or franchised installer is considered to be most likely to be acceptable to owner occupiers who want locally based companies with a trading

history they can easily verify through friends, family and neighbours. This could prove the easiest to scale at pace once the initial infrastructure can be developed.

Large corporate delivery organisations will continue to appeal to the social housing sector, but have potential to supply multi-property landlords and perhaps over the longer term to owner occupier delivery; this however will require changes to their methods of sale and contracting arrangements.

National Repair Maintenance and Improvement companies have established markets for single measure retrofit and are already moving towards multi measure installation. These companies have an established customer base, mostly older middle income families who they continue to deal with for a number of interventions on their homes with typically 3 improvement projects, each of under £10,000 per bite.

Companies currently delivering or considering retrofit have concerns about entering the market, among them are:.

- Who pays for the survey?
- Certainty of payment
- Carrying liability for installations for up to 25 years
- Complexity of VAT rules between repairs, retrofit and new extensions.
- Continuity in government policy, incentives and regulation.

Capacity for whole house retrofit is currently considered to be approximately 100,000 properties per year. This could respond to a doubling of demand in approximately a year; using existing materials, methods and trade-skilled labour. To achieve capacity to deliver 400,000 units per annum by 2020 training and accreditation systems will be required to qualify 7,500 retrofitters and 1,000 surveyors per year across the UK. This will achieve the 50,000 retrofitters and 7,500 surveyors needed to meet this demand.

New qualifications and competent person schemes are emerging for retrofit and survey with simple accreditation systems which cut across the current product / trade boundaries and are trusted by consumers.

Capacity to supply materials to meet demand is not considered to be a limitation other than in new and emerging highly effective products such as Aerogel where the benefit of thinness has clear advantages for particular problem areas in homes such as around window reveals.

2 Background and link to other work packages

Buildings are responsible for 40-50% of the national primary energy consumption in the UK, half of which is used in domestic buildings for lighting, heating and cooling. More than 85% of the UK's housing stock in 2050 will be dwellings already built today. Only a fraction of 1% of which have been proven to have adequate thermal performance to meet the UK's energy targets. To meet the UK's commitment of reducing CO2 emissions by 80% from 1990 levels energy demand for domestic use must be reduced. The Energy Zone Consortium Project is focussed on reducing domestic energy consumption through increasing thermal efficiency of domestic properties. The project is divided into 6 work packages:

Work Package 1 -Understanding thermal performance of the housing stock at an individual dwelling level.

Work Package 2 - Impact of thermal efficiency measures on the UK housing stock. *This has illustrated where people from different customer segments are likely to live and in which house types.*

Work Package 3 - Developing retrofit solutions to improve thermal performance of our national housing stock. *To date this has included analysing house types, tenure and occupancy followed by the development of standard retrofit approaches for the different house types. The supply chain has responded to these and the results are contained in this report.*

Work package 4 - Developing a sustainable supply chain to deliver whole house retrofit on a national scale. In this work package the hypotheses and supply models developed in work package 4.2 have been tested, the processes of Survey and Installation have been built upon and refined and different supply chain configurations tested.

Work Package 5 - Understanding customer value & maximise the take up of retrofit. *Work completed on this work package has led us to understand which customers are most likely to take up retrofit*

Work Package 6 - Developing the policy and regulatory framework to manage, support and encourage whole house retrofit.

This report presents the refurbishment supply chain implications for whole house retrofit for improved energy efficiency.

3 Approach

The objective of Deliverable 4.3 is to take a broad view of the supply chain requirements for whole house retrofit and evaluate how prepared the current supply chain is to deliver; then to propose solutions that enable transition at sufficient pace.

3.1 THEORY

Right to Left Thinking

A central premise of the research is that Market Demand (pull) is crucial for successful Mass Scale Retrofit. The most successful new market offerings are designed *Right to Left* – starting with customer desires (right of page) and building back to design and materials (left); rather than improving what exists until the market is content with the offer. As a result this project focuses first on meeting the householders' needs and desires and then technical solutions by house type follow rather than lead.

The sequence is crucial to design a system which:

- Eliminates waste and risk.
- Maximises quality and customer satisfaction.
- Minimises whole system cost.

The first stage is to clarify the Value Proposition – **What** the customer wants from retrofit. The steps were as follows:

- Test the customer needs hypotheses developed in WP 4.as part of the customer research methodology. Specifically: survey, installation process, through life performance and support. This is covered in the WP5.4 report.
- Refine the requirements in terms of: performance, speed, quality, flexibility and cost as inputs into the WP3.4b single dwelling solutions.
- Translate these requirements into a specification of product and process for survey, installation and through life.
- Develop approaches which, as far as possible, meet all requirements.
- Quantify any gaps in capability and propose solutions to overcome them.

These steps are detailed in Chapter 4 and onwards

Lean systems thinking

Lean thinking allows the creation of enterprises free of defect deviation, delay and waste in all its forms;. Minimising transport and the number of hand offs in the supply chain minimises cost, reduces stock and work in progress and maximises velocity. Reducing the cost of retrofit is a prime objective defined within WP 5.4, as cost comes above all customer requirements including speed and disruption the supply chain designs following are a result of combining right to left and lean system design, the results are the least wasteful supply chain we can imagine.

Using Lean Systems thinking we then develop the Value Delivery mechanism – **How** the customer requirements are satisfied; we can:

- Conceive a waste free delivery approach where there are no defects, delays or duplication and where there is no excess stock or capital investment.
- Contrast with current delivery capability – not only in the current sector.
- Decide whether it is viable to create waste free capability in the short term; or whether organisations will develop such capability over time.

In the light of the updated customer and design requirements, the different delivery mechanisms identified in the work package 4.2 report were reassessed for their potential to deliver mass refurbishment across the Owner Occupier, Social Housing and Private Rental sectors.

In parallel with the above an assessment can be made of the delivery demand required to achieve sufficient pace and scale of retrofit to meet the UK's 2050 climate change objectives.

4 High Level Supply Chain Design

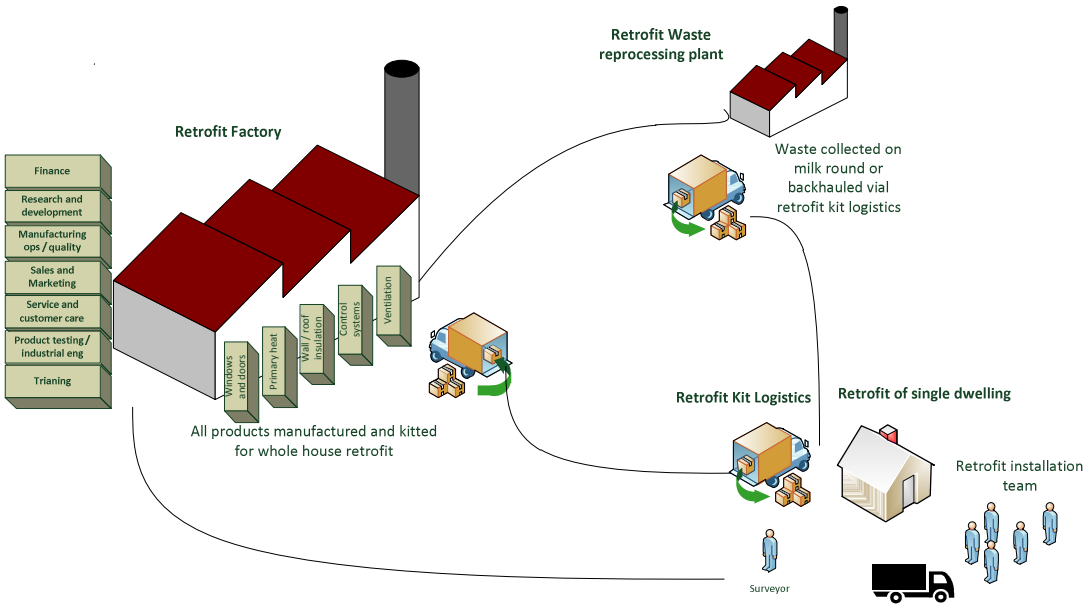
Work package 4.0 presented a graphical illustration of the existing supply chain, which is configured to deliver materials and product as required to tradespeople. This is usually consolidated on site or piecemeal via pick up from or delivery by trade merchants.

Work Package 4.1 presented a possible supply chain configuration which eliminated the inefficiencies of the current silo based supply chain; for this report a more effective solution was sought. Using the right to left approach the "least wasteful" high level supply chain emerged which avoids multiple handling points for materials and products which increases cost.

For this report the right to left supply chain design is presented here in 2 new models.

- The least Wasteful Supply Chain with Retrofit Kit Factory
- Consortium of manufacturers a Kitting Plant.

Figure 1 Least Wasteful supply chain configuration



Retrofit Kit Factory

This configuration consists of a retrofit kit factory making all products needed during the installation of whole house retrofit measures. This clearly avoids a separate consolidation point and minimises transport losses. It is arguable to what level the plant could make everything. Component level items (screws, fixings, sheet metal) could be bought in rather than manufactured on site. It is however conceivable that all products could be made on site (with only raw materials as an input), processed and kitted ready for delivery to site in specially adapted vehicles delivering product just in time, and configured to provide easy access to parts in the sequence they are required. The kit pack could then be used as a waste segregation unit ready to be backhauled to the waste processing plant. It should be an aspiration to achieve "zero waste to landfill" as a result of retrofit.

This is the model against which all future supply chain configurations should be judged in order to guide us towards a "waste free supply chain".

To develop a national network of this model would require major investment in sites and manufacturing plant, or a shift of use for existing networks.

Investors in this type of model could include large corporations currently delivering infrastructure projects, major facilities management groups managing out-sourced government contracts, utilities companies or logistics groups.

Waste Processing Plant

The retrofit waste processing plant consists of a factory unit specifically set up to process retrofit waste. Materials such as glass and UPVC, aluminium and steel from windows are valuable commodities which can be readily reprocessed. The UPVC could be fed directly back into the retrofit factory for extruding into new window section, other UPVC products such as facia boards or eaves details..

Building waste such as wood may be chipped and incinerated or cleaned / processed and chipped for use as biomass fuel. This could offer the opportunity for the plant to generate some of its own energy required for day to day operations. More problematic are floor coverings. Carpet and Lino are more difficult to reprocess. The operation of the reprocessing plant could be manned significantly with either "back to work" labour schemes or by offenders.

Surveyor

The survey would occur as described elsewhere in this document. It is unclear how this could most effectively be integrated into this model, options include self-employed, contracted or fully employed surveyors. The survey if not funded or subsidised by government or energy companies would need to be paid for by the homeowner or the parent company in this model. The potential value of the data produced during the survey could offset some of the cost of the survey itself.

Installation

In this model the scalable unit could be a highly effective delivery vehicle. The delivery unit pulls material from the retrofit kit factory and is kept up to date with process and material developments as part of its operating license agreement. Overall liability could be shared with the corporation owning the retrofit kit factory resulting in low entry cost for new delivery units. This is likely to be a highly versatile and fast method to deliver capability and reach for whole house retrofit

Alternatively it is feasible for the hybrid model to be deployed in this configuration with the capital costs of set up being borne by a large enterprise and others taking ownership of survey, installation, logistics and waste processing and recycling

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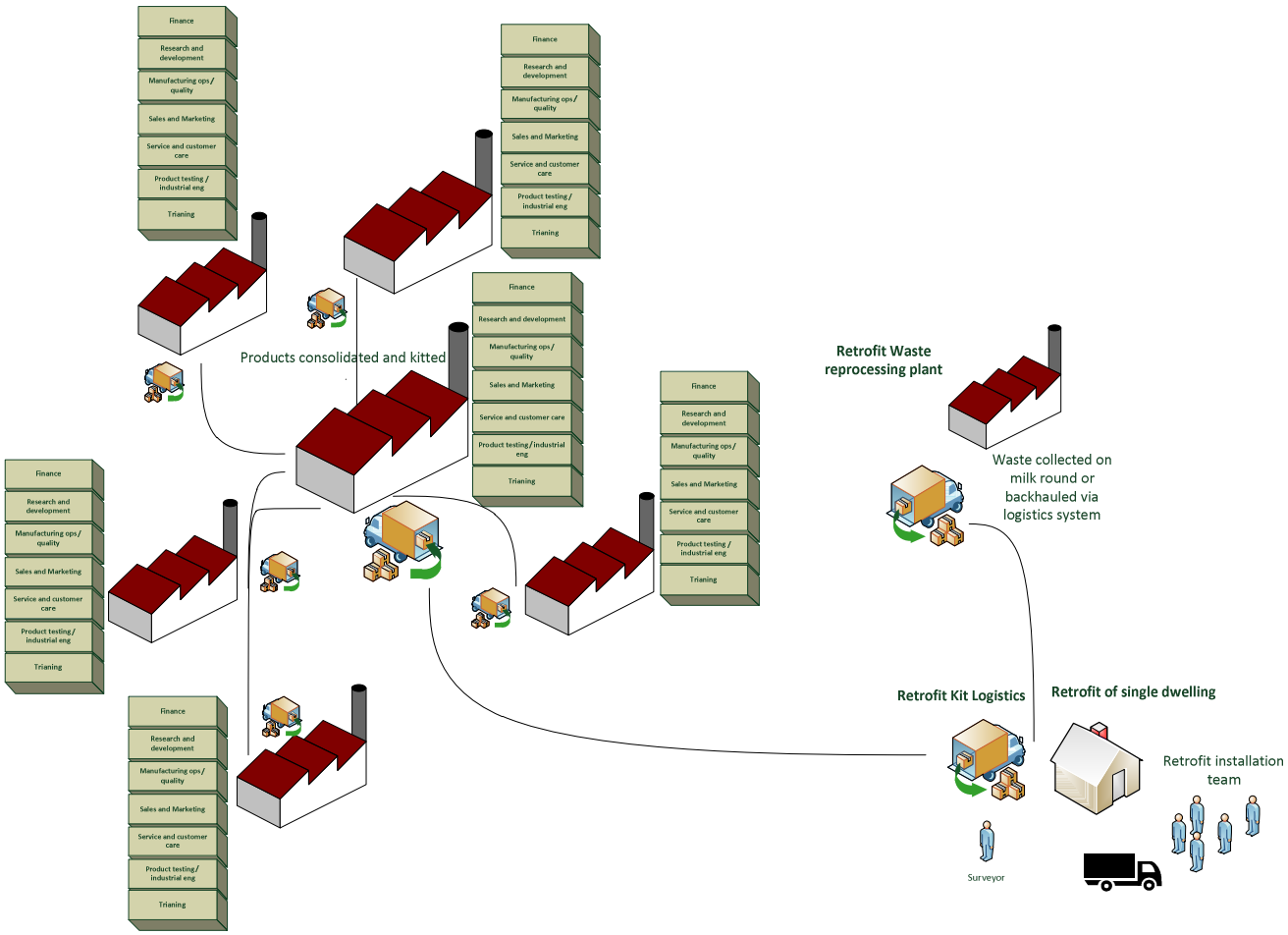
Figure 2 Manufacture with kitting plant / consolidation centre (could be a manufacturer)



The above model consists of a series of product manufacturers who feed product to a consolidation / kitting entity. This could be a major product manufacturer, a merchant or an independent processing plant. It is likely that a consortium would be assembled to deliver this model. There is greater transport waste in this model but the final delivery leg is the same as the "retrofit kit factory model". Operational risk could be shared by consortium members. However, overall control and ownership of process development and improvement is complex. Again retrofit installation could be delivered by a scalable unit or the hybrid model could be deployed.

5 Detailed supply chain design.

5.1 INPUTS TO THE DESIGN PROCESS

Customer Inputs

Drawn heavily from the structured householder research in WP 5.4, but contrasted with previous Work packages and other projects.

Technical Design Inputs

The design inputs came from a series of workshops as part of WP 3.4b.

Supply Chain Inputs

Views and insight from companies from the existing domestic retrofit sector and other organisations from the construction supply chain were sought to test our delivery models. Their responses gave a broad picture of the potential market, but areas of particular focus for the team were their views on:

- The viability of each model of retrofit supply.
- Their own organisation's current capability and interest in delivering whole house retrofit at a mass scale
- Whether government initiatives are likely to stimulate growth in demand.
- Their assessment of gaps in, current capability.

Companies from the following industries contributed (See Appendix C):

- Construction / construction management
- Insulation product manufacture
- Construction product supply and distribution
- Logistics
- Construction waste management
- Replacement windows and doors, manufacture and installation
- External and internal solid wall insulation installation
- Cavity wall and loft insulation installation
- Primary heat source product manufacture
- Construction training and certification

Discussions added to the understanding of current capacity, capability (product and process), and obstacles to market growth, trends, and conditions under which the retrofit refurbishment market might grow rapidly.

6 The Survey Process

6.1 Survey Design

The value propositions developed for retrofit give a 4 hour time window in which to carry out a complete survey to understand everything about a property. From this to be able to understand current energy performance, design an intervention, accurately cost and manufacture all components and plan the embodiment. There is a limitation in performing only one survey which is explained below. In addition there is a great deal of information to collect and many checks to the fabric of the building.

The survey process performs 4 main functions

- It is the gateway to a sale
- It will produce the information needed to understand the construction of the building, its condition and other relevant factors to allow appropriate interventions to be designed and planned; with sufficient rigour it will also provide certainty of the cost of installation of the planned measures.
- It will allow the current thermal performance to be evaluated and the benefits of the planned intervention to be quantified
- It will produce the dimensional information required for the fabrication and provision of products required for the intervention

The required outputs of the survey process were developed in a workshop setting using the outputs form the process Failure Mode Effect Analysis completed in WP 4.2, plus existing material available from:

- The decent Homes Programme survey
- The BRE energy performance certificate survey
- SAVA home condition survey
- 17th Edition domestic electrical installation report survey
- Homeowner gas safety test survey
- Heating survey questionnaire
- BS 7671 Survey forms

The final output from the workshop includes an assessment of:

- Competence required for each task and if specialist knowledge / qualifications are needed
- Time required to compete tasks
- Equipment and tools needed to carry out the survey

6.2 Survey Workshop Process

A workshop was held to analyse the outputs needed from the survey and process needed to acquire them. During the workshop it became clear that there are several difficulties to overcome.

- The need to make the survey effective
- Collect all the information and data required for retrofit
- The need to only collect the required information and data;

As the intervention design is carried out post survey it is likely that over-processing would be built into a one stop survey. In addition there would be no contract in place with the client when a one stop survey took place, should invasive work be needed or dangerous appliances / installations discovered the surveyor would be compelled to condemn and disable them. This is a major drawback.

To resolve this it is considered more effective to split the survey into 2 visits

- Visit 1: To collect sufficient property information to allow a technical solution to be fully developed and a budgetary price to be put to the client subject to the invasive survey.

After a contract is agreed

- Visit 2: To deliver highly accurate dimensional and condition information giving certainty and data for programming, off site manufacture of windows / doors and insulation products. It is likely that invasive tests are more likely to be acceptable after a sale has been agreed.

It is considered unlikely that commercial organisations would be prepared to carry out a full blown one stop survey with no certainty of a sale unless the survey is fully funded. It is however considered to be feasible to carry out a comprehensive survey for retrofit in 4 hours, although the programme developed here suggests that 3 people would be needed on site. A great deal of information could be collated remote from the property which would improve this if data relating to property, tenure, occupancy, income were available from a central source. Currently this is held by various agencies, some is difficult if not impossible to access.

6.3 Proposed 2 stage Survey Process and Programme

The survey process has two key stages:

1 To inform the process of selecting the most appropriate retrofit measures for reducing CO2 emissions (fuel costs), that are aligned to the long term needs of the building and its occupants.
2 Provide the technical detail and measurements which allow for the manufacture/ordering of intervention components, the sequencing and programming of the installation, and cost certainty from specific risk identification.

Stage 1

A stage 1 survey results in the client being presented with a range of personalised solutions, offering choice in terms of price, predicted energy savings , programme and levels of anticipated disruption.

In order to develop design solutions the stage 1 surveyor needs to capture:

1. Current energy use
2. Planned or desired changes to be included in the works
3. Potential blockers

Current energy Use

To model energy use of a dwelling 4 categories of data are needed

1. Building Fabric –Information on the built form of the property, dimensions, construction type and current methods of ventilation.
2. Services – Details on current methods of space heating, water heating, lighting, cooking and appliances.
3. Life Style – Understand how the building is used by its occupants.
4. Geography – Understand geographical influences to energy use, such as orientation, exposure to wind and rain and local weather influences.

Some survey information *must* be completed on site although some information can be obtained off site and confirmed during the site visit. None of the information required in the production of the energy assessment requires specialist knowledge but does require the surveyor to have an understanding of the components they are observing. The time taken to complete a survey is related to the size of the building and the complexity of its built form, however a realistic target is, 2-3 hours on site with current methods.

The use of data based computer models; thermal photography will enhance the understanding of energy use, specifically for thermal bridging. Ideally this should be

conducted during the site visit, this can be conducted usually on the front elevation without site access. Thermal photography must be conducted when there is a significant difference between internal and external temperatures meaning there are limited times when this can be done, but when possible is encouraged.

People	Time on site	Equipment	Skills
Surveyor	2-3 Hours	Camera Video Camera Thermal Camera Laser measure Tape measure Step ladder Torch Data capture device Water flow meter Compass	Basic understanding of construction methods and building services. Able to use data capture tools. Ability to conduct computer based research.

Planned or Desired Changes

To ensure the design solutions are aligned to the long term needs of the building and its occupants, the survey must capture planned or desired changes affecting energy use. These changes can affect any or all of the four assessment areas and each must be covered by dialogue with the occupants.

Examples of the planned / desired changes to building fabric include plans for extensions or loft conversions, renewable energy sources, local plans for community CHP or specific requirements for example an Aga cooker. Lifestyle alterations make significant changes to energy use and therefore capturing information such as plans for children or forthcoming retirement etc. is essential. Less usual although possible are potential changes to geographical influences, such as planned deforestation, new flood defences etc.

Whilst some potential changes can be captured away from site the interaction with the client will provide the best and most accurate information.. Questionnaires can capture more usual data but dialogue with the client is essential so the surveyor must be able to communicate with the customer in an effectively and professionally

People	Time	Skills
Surveyor	1 Hour	Effective communication and listening skills. Ability to conduct computer based research.

Potential Blockers

Potential blockers are factors affecting the range of possible retrofit solutions. The stage 1 surveyor must understand factors affecting the various interventions and ensure they are identified during this phase. Factors include:

1. Finance – The ability of the client to finance the works will certainly determine the level of intervention. The survey needs to identify an acceptable range in which to develop solutions.
2. Condition – The condition of the existing building fabric and services has to be able to accept proposed interventions.
3. Legal issues – Conservation areas, planning permission, covenants, building regulations and the Party Wall Act must all be satisfied.
4. Location of existing services and fixtures.
5. Internal and external access.
6. Health and Safety – The presence of asbestos, damp, radon, protected or dangerous plants / animals and vulnerable people.

Assessing the condition of existing services and building fabric is problematic. Firstly much of a dwelling, especially during a stage 1 survey, is not visible to the surveyor. Roof and loft spaces, under floor voids, wall and inter floor cavities and behind fixed furniture are all partially or totally unobserved, unless intrusive and destructive methods are employed. Secondly when defects are identified, their true cause is often a case of perspective until further information from monitoring or exploratory works is concluded. Finally only suitably qualified and insured people are allowed to test and inspect gas and electric services, which are currently beyond the scope of the average surveyor today.

To minimise time and disruption on site, the stage 1 surveyor will only make general comments on the condition of the fabric and services, to ascertain whether an intervention can safely be included in the proposed solution or not. Should defects be identified on site, the matter will be referred to specialist structural, asbestos, electric or gas engineer to determine what further actions are required.

Many potential blockers can be identified off site and then confirmed with the client or during the visit. Condition must be assessed on site and can be undertaken in conjunction with the energy use data capture.

People	Time	Equipment	Skills
Surveyor	1 Hour	Damp meter Camera Video Camera Thermal Camera Laser measure Tape measure Step ladder Torch Data capture device Water flow meter Compass	Ability to conduct computer based research. Basic understanding of building defects and their causes. Understanding of legal issues pertaining to building and refurbishment. Asbestos aware. Knowledge of the possible interventions and their installation requirements.
Structural Engineer	As required	Off site Review of data captured	
Asbestos	As required	Off site Review of data captured	
Gas Engineer	As required	Off site Review of data captured	
Electric Engineer	As required	Off site Review of data captured	

Summary

The stage 1 survey gathers the information needed to design potential solutions which best meet the requirements of the dwelling and its occupants.

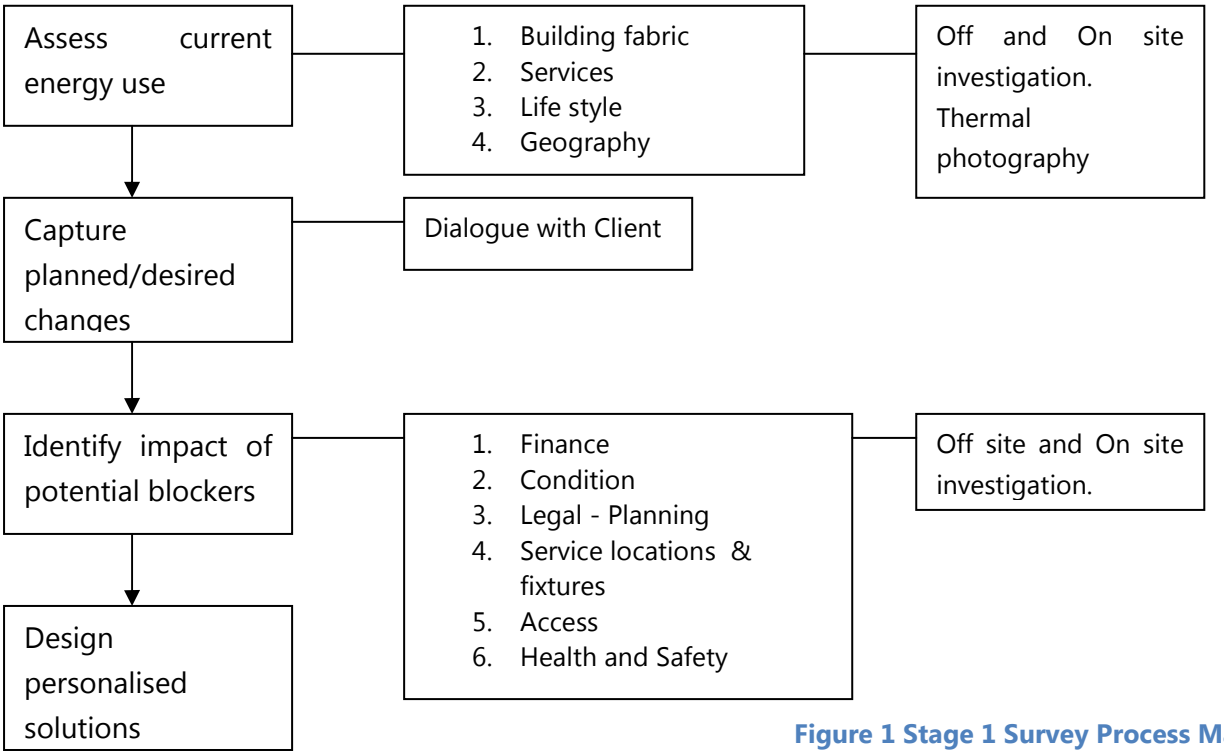


Figure 1 Stage 1 Survey Process Map

The survey will take approximately 3-4 hours of site/client based research and can be undertaken by a single person with an understanding of construction methods, building services, building defects and their causes, legal matters relating to building and refurbishment, asbestos awareness and knowledge of the intervention installation requirements. The surveyor must be able to use data capture devices, undertake computer based research and be an effective communicator. Where appropriate structural, gas, electric and asbestos experts are to be utilised to help determine the feasibility of interventions and whether further investigative site visits are necessary.

A successful stage 1 survey will result in the client being presented with a visual range of personalised solutions, which offer choice in terms of outline price, energy savings achieved, levels of anticipated disruption and programme.

Stage 2

The stage 2 survey will only occur once the client has **confirmed** their preferred design solution and willingness to proceed, this seeks to capture the technical details and measurements which will allow for:

1. Off-site manufacture of relevant components
2. Ordering of equipment and materials
3. Sequencing and programming of the installation
4. Cost certainty from specific risk identification

The client must be informed that elements of this survey will be both intrusive and destructive in nature. In addition, as professionally qualified experts will survey the property, should they identify any faults which pose a risk to health and safety, they are obliged to immediately condemn and shut down any offending appliance or system.

Due to the significant costs of this survey the client should be prepared to demonstrate a level of commitment to the project by either paying for the survey and making good costs or progressing to full purchase of the retrofit package.

To meet the customer requirement of minimum people coming to their property, it is proposed that the stage 2 surveyor will be a member of the retrofit installation team. This will also ensure that the installation team already has some familiarity with the client, the project, its risks and programme when the installation commences.

The stage 2 survey will need to ascertain, for the main dwelling and any extensions, the presence, location, condition and 3 dimensional measurements of all the elements captured in the table below.

Survey Elements Table

Loft	EWI	IWI	Floors	Doors-Windows	Heating	General
Boarding	Balconies	Baths / sinks / showers / toilets	DPC	Aspect	Appliance age	Access
Chimneys	Bay windows	Bay windows	DPM	Cat / Dog flaps	Appliance location	Asbestos
Damp, rot, animals and fungus	Brickwork	Chimneys	Existing insulation	Cills	Back boilers	Electrical services / penetrations
Dormers and Velux windows	Burglar alarms	Cills	Floor boards	Colour and finish	Boiler	Gas Services / penetrations
External walls	Cills and lintels	Cold bridges	Floor covering	Design	Controls	Water Services / penetrations
Fire hazards	Damp and mould	Coving	Floor fixings	Door furniture	Doors	Data-comms services / penetrations
Flues	DPC	Curtains and blinds	Floor joists	Door type	Electricity meter type	Structural integrity
Gutters	Eaves	Damp / mould	Floor levels	Draught proofing	Existing insulation	Ventilation
Insulation	Existing insulation	Decorations	Ground type	External walls	External walls	No. occupants
Internal roof space	External lighting	Door /window frames	Internal stairs and risers	External wall finish	Flue	Age of occupants
Loft hatch	External walls	Door /window reveals	Joist to wall interface	Fixings	Gas main	Pets
Orientation and pitch	Fascias, soffits, bargeboards	Doors /windows	Services	Frame	Gas meter	Material storage
Party walls	Fixtures, fittings and accoutrements	Electric sockets and switches	Skirting	Glazing	Gas pressure	Waste storage
Penetrations	Flood risk	Existing insulation	Under floor heating	Height from floor level	Gas tail	Boundaries
Possessions	Flues	Fire places	Void	Internal wall finish	Heat emitters	Public areas
Roof covering	Ground levels	Fitted furniture		Letter boxes	Incoming Services	Possessions
Roof membranes	Ground type	Floor construction		Line	Make	Children
Roof timbers	Lightening conductors	Floor finishes		Lintels	Model	Security
MVHR	Manholes and drainage	Floor levels		Location	Pipe lagging	
Verges, eaves and soffits	Meter housing	Flues		Locks	Room dimensions	
Working lights	Orientation	Heating controls		Number	Stop cock	
	Overhead obstructions	Inside of external Walls		Opacity	Storage unit capacity	
	Plants and vegetation	Internal doors and openings		Opening direction	System type	
	Porches and conservatories	Kitchen appliances		Reveals	Wall or Floor mounted	

	Rain water goods	Kitchen cabinets		Structural opening	Water pressure	
	Services	Party walls		Thermal bridges	Water tank insulation	
	Soil and vent pipes	Possessions		Window type	Water tank size	
	Taps	Radiators and pipe work			Windows and doors	
	Thermal bridges	Service penetrations				
	Wall finishes	Shelves				
	Wall ties	Skirting				
	Window and door frames	Wall finishes				
	Window and door reveals	Wall lighting				
	Windows and doors					

For all properties a number of standard inspections will take place, regardless of the designed solution, to ensure there are no obvious dangers to health and safety. These will include:

- Gas safety inspection
- Domestic electrical inspection and test
- Refurbishment and demolition asbestos survey (Occupants can be present during tests)

In addition to the standard inspections the following test will also be taken depending upon the designed solution.

- Pull out test, to establish structural integrity for EWI.
- Wall tie inspection, to establish structural integrity for EWI
- Structural strength calculations of walls, lintels, joists and rafters for EWI, IWI and loft insulation
- Outdoor CAT Scans to identify buried services
- Cable and pipe work scans in floors and walls
- Borascope cavity wall inspection of existing insulation condition
- Thermal imagery if appropriate

Dimensional aspects of the survey may be completed using laser scanning equipment which will enable the production of a 3D model of the skeleton and structure of the building. This data will be key in the off-site manufacture of wall, floor and loft insulation as well as new doors and windows where appropriate.

Once the 3D model has been created all the information captured such as the service runs, location of key appliance etc. can then be overlaid upon the skeleton model. It

is envisaged a Building Information Management (BIM) type system will capture this information and be held in a "fully surveyed dwelling database" which will be available for future works to refer to avoiding additional surveys and cost.

Survey / Inspection	When applied	Skills / Qualifications (or similar)	Time (hrs)
Gas Safety Survey	All cases	Gas Safe	2
Electric Test Inspection	All cases	NICEIC	3
Asbestos survey	All cases	UKATA	2
Pull out test	EWI		1.5
Wall tie inspection	EWI		2
Structural calculations	All cases	ICE	Off site
CAT scans	EWI		.5
Cable and pipe work scan	IWI / Floor		1
Cavity inspection	EWI	NIA, CIGA, BBA	1.5
Thermal imagery	All cases		.5
3D Scanning	All cases		4
Possession testing	Internal works		1
Ventilation	All cases	HVCA	
Loft survey	Loft		.5
EWI survey	EWI	INCA	1
IWI survey	IWI		1
Doors and windows survey	Doors &Windows	FENSA	1
Heating survey	Heating	HETAS	1
Floor survey	Floor		1
			24.5

Time taken to complete the survey will depend upon the size of the property, but the table above demonstrates that a survey for:

- EWI and all interventions will take 22.5 hrs
- IWI and all interventions 19 hrs

There is scope to reduce the time taken by:

- Only surveying for relevant interventions and not whole house
- Develop tools and equipment to facilitate faster data collection/testing
- Efficiency gains as the process becomes more practiced
- Using a Risk Based approach to potential problems possibly insuring against subsequent unforeseen consequences.

Due to the wide range of skills and training necessary it is possible up to a maximum of 3 people will be required to complete the survey within a one day visit. It is suggested at least one of the stage 2 surveyors should be part of the retrofit installation team. The survey provider must possess a range of multi skilled staff to provide appropriate skills coverage for each dwelling survey. Specialist skills to deal with oil, micro generation etc. have not been covered, but may be required.

The survey process will expose the surveyor(s) to certain identifiable risks. ;relevant risk assessments and method statements will need to be developed to mitigate these factors. Reference to the FMEA study carried out for WP4.2 will help prioritize the most significant risks. Specialist skills to deal with oil, micro generation etc. have not been covered, but may be required.

Summary / Gap Analysis

The stage 2 survey will only occur once the design solution has been completed and the client is prepared to commit either to the cost of the survey or progress onto full installation. A successful survey builds on the information capture during stage 1 but seeks to minimise risk by engaging in more definitive inspections which will incur minor damage and disruption to the occupant. Risk reduction in turn allows for greater cost certainty which benefits both the contractor and client.

Capturing of dimensional measurements is critical to allow for off-site manufacture of components as well providing the detail necessary for structural calculations. The development of 3D scanning and the software to overlay additional information is a key area of development to enhance this survey process and reduce time on site.

In order to meet the customer requirements of minimum people on site we propose the stage 2 survey is carried out at least in part by the installation team. This has the additional benefit of ensuring the installation team already have familiarity with the project, property, client, risks and programme when installation commences.

Finally, the stage 2 survey seeks to capture all the information necessary to undertake any intervention in one visit and save the costs of multiple surveys. In order to comply with current regulations the skills and qualifications necessary are extensive. The survey provider needs to be able to draw on a pool of multi skilled people to match the dwellings requirements. Training and accreditation should be specifically designed to accommodate this need, or new methods of data capture developed.

Improving the Survey Process.

Current estimates result in the following estimated process timings.

Stage 1 Survey 4 Man Hours

Stage 2 Survey EWI 22.5 Man Hours

Stage 2 Survey IWI 19 Man Hours

The above assumes a comprehensive survey is carried out recording all dimensional and condition information relating to the property. It is likely that as experience builds about house types, age etc. patterns will emerge and common problems will be easier to pick up and some tests reduced from 100% to a sample basis.

The process timings above will be tested and challenged in WP.4.4; Lean improvement methods will be applied with the objective or reducing time taken and maximising "right first time" performance. The objective must be to reduce the time taken at first survey to 2 man hours and at second survey to 8 man hours this will be the challenge taken into WP4.4.

6.4 Survey output data and the need for a data strategy

The survey will result in the recording of data which has a potential commercial value. Details about a property, the occupants, tenure, condition etc. will all be collated.

Capturing, storing and keeping information up to date for future use is collectively referred to as retrofit data-strategy. As with all data, the relevance and timeliness of the data is directly related to its value. To create a process to retro fit existing housing with products that will enable the home owner to lower their use of energy and in turn reduce carbon emissions, the primary use is to capture, store and reuse data. Data can however also be purchased to add valuable insight to the details of localities, homes and homeowners and can also be sold or shared with 3rd parties who can reuse the information for commercial benefit. The key areas to focus on for the Retrofit Project are,

Locality, House Type and House holder

- What data is available or can be calculated to evaluate key criteria for cost benefit and payback (eg. Loft insulation low cost, low disruption as opposed to IWI, high disruption and cost) to establish best possible CO_2 reduction possibilities. (Eg 1930's 3 bed semi house versus 1970's town house).
- How can this data be used to identify the key criteria for marketing the best possible cost / benefit home types?
- What data is available to procure that can help build a picture of the target household prior to a visit to reduce survey time and disruption?
    a. House - type, age, relevant locality data, conditions, utility usage, existing building regulations, plans, etc
    b. Householder – Number of occupants, income, age, length of tenancy, living habits.

  All the above are available on the data market.

Detailed Survey, Product and Build Data.

- Data Collection – what data can be collected during each part of the value stream (research and development, pre sales, sales, survey, install and through life process) that can be cross utilised to support another step. Eg. keeping key data for any products installed (make, model, serial numbers etc) is critical to the through life warranty process.
- On-going household development – data captured throughout the process should be maintained and easily available to assist in further household development work (eg loft conversation / extensions etc). Keeping the data could significantly reduce the time and cost of further surveys.
- Continuous Improvement / Supply Chain Planning. Capturing data during installation on the time taken to complete tasks will aid in the analysis of the process for continuously improving the efficient of retrofit delivery. This data will also be utilised as a pull signal for the Just in time supply of materials to site, reducing unnecessary inventory and waste.

3rd Party data sales

- Considering the depth and detail of data that could be capture and consolidated into a single database from each step of the retrofit process, there is potentially a valuable commercial proposition around selling this data to 3rd parties or sharing within the wider government framework. Private organisations such as Retail, Utilities and Construction as well as Public Sector organisations such as HMRC, DWP, Environmental Agencies and local councils would all be interested in up to date, relevant house and householder information.

Data security and protection will need to be considered carefully especially if the intention is to share or sell the data collected. Data protection and particularly compliance will need to be considered even if data is to be sold or shared with 3rd parties. If the intention is to use the data in any point in the future, even for another product, within the same company the consumer must be made aware of the . It is best practice to obtain all data rights up-front by asking customers to sign an acceptance for their data to be shared for 3rd parties as part of the commercial sales process. This is backed up by sharing a copy of the company data protection policy.

The value of the data produced may influence how the survey is funded. This could be part of the obligation placed on energy companies and be funded in full or in part, the data produced may then be traded generating income offsetting the survey cost. Alternatively it could be paid for at least in part by the consumer; although work carried out for work package 5 suggests there is a low cap on the price householders would be prepared to pay.

A 2 stage survey process will minimise the up-front cost of surveying property prior to a qualified sale being generated.

Gaps and Shortcomings

The skills needed for the surveyor and the precise sequence and method of working are not yet sufficiently understood. The predicted time for the survey is far too great and new methods and possibly a risk based approach to potential existing defects in the building fabric may be a step to reducing this. It is most likely that a range of plant / equipment technical solutions etc. and improved methods and experience will be needed in combination to achieve the stated objective. The skills required and the methods to develop these in the correct mix to cover the existing housing stock are outlined but need specification in detail. In addition a less conservative approach to possible defects in the approach to surveying is needed in a new breed of retrofit surveyors.

7 Installation Process

The value propositions developed in WP 4.1 state that an installation time of 1 to 2 weeks is required to achieve mass appeal for whole house retrofit across our target customer segments. A series of technical retrofit solutions were specified within WP3.4b to achieve the required thermal performance for each of the house types relevant to the target customer segments most likely to take up whole house retrofit. These were then used to plan how these would be embodied. This shows that the one to two week window for installation can be met for all house types and planned technical solution embodiment. The challenge remains to manage disruption for the homeowner if they chose the "Work around me" option rather than "move me out" however as the table below illustrates, there are only 2 property types where there is a time advantage in retrofitting an unoccupied property.

Summary of retrofit programmes by house type

	Pre 1919 Detached		Pre 1919 Mid Terrace		1919-44 Semi		1945-64 Semi		1965-80 Bungalow		1965-80 Detached		1965-80 Flat		1980 on Detached	
	Vacant	Occupied	Vacant	Occupied	Vacant	Occupied	Vacant	Occupied	Vacant	Occupied	Vacant	Occupied	Vacant	Occupied	Vacant	Occupied
Peak Manpower	4	4.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Programme Days	7	10	5	5	7	7	7	7	2	2	7	7	2	2	8	8

The above programmes illustrate that a team of 4 is needed at peak labour need, to carry out the retrofit in the specified time. To cover the tasks which are necessary but not included in the programme plans a fifth team member is recommended to cover Site management, customer liaison and planning. Skills required by the team fall generally into four categories.

Full retrofit programmes for the 8 house types above are included in this document as Appendix B

Skills knowledge and qualifications required by the team include:

- Programme planning and management of works on site
- Quality control
- Customer contact, manage expectations and complaints.
- Gas, water and electrical installations – *Dynamic systems and measures*
- insulation products, air tightness measures, draught proofing – *Static measures*
- *Precise working* and general building / roofing

As previously stated the scalable delivery unit working with a retrofit products supplier under license presents an attractive delivery vehicle for mass retrofit. The suggested potentially "least wasteful supply chain" configuration in partnership with

this model would appear to offer the clearest lines of communication and responsibility together with effectiveness. Organisations likely to have the resources and power within the supply chain to make this model work are large manufacturers of some of the base retrofit products, national merchant chains working in construction, large companies running large infrastructure or complex facilities management projects.

Gaps and Shortcomings

Current trade based training, accreditations and material / product supply chains reinforce trade boundaries and do not support the idea and practice of the multi skilled retrofitter. This report suggests different supply chain configurations to overcome these shortcomings but a comprehensive rethink on how trade bodies, regulation, training and accreditation inter link and interact and how the existing trade silos can be broken down in retrofit. This is essential if the team of 5 is to be realised and time to retrofit continually reduced.

8 Through Life Support

Initial thinking for through life support was for the installing organisation to use insurance backed warranties covering the work that they carry out. This would provide some degree of customer comfort but the long life of retrofit products present some concerns over who will liable for problems over time. This requires further work with members of the supply chain and the insurance / finance industries.

A s suggested in this report to reduce the up-front cost of retrofit a new model for domestic equipment provision is possible through lease/ maintenance contracts, this scheme could be part of the whole house approach and cover other aspects of retrofit which cannot be leased.

Leasing with service contracts is considered ideal for system components such as heat pumps and boilers. A drawback of this system is the fear that individual manufacturers' products could be "De-Listed" by some trade outlets if alternative supply and distribution models are pursued outside of their distribution networks.

8.1 Gaps and Shortcomings

The requirements for installation and survey for retrofit have been designed informed by the customer requirements and the design of effective and efficient interventions. The through life support process will be studied in depth as part of WP4.4 and the processes developed in WP 4.2 will be built upon.

9 Supply Chain System Design

Building on the work carried out for Work Package 4.2 where several different types of organisation were considered to deliver whole house retrofit. These were:

- Leave it to the Market
- Scalable unit
- Large Corporate deliver. *Now called National Specialist*
- Hybrid
- DIY

Each of these models has been the subject of further consideration for this report.

9.1 Leave it to the Market

As stated in the report for work package 4.2, this option is unlikely to result in the required step change in delivery cost, speed and performance required to meet the value propositions developed. The required level of collaboration and challenge to the status quo is highly unlikely to be achieved without abrupt disruption of the market. The existing trade silo approach will not deliver the required speed, cost and quality requirement to meet customer needs. In addition this is unlikely to lead to standardised approaches to training, installation methods, and quality control which will be required to guarantee effective long term results and customer confidence.

9.2 National Contractor

Headline attributes

- Deliver to Social Housing on a large scale
- One sale = Many Homes
- Delivery trade labour is Sub Contracted
- Silo'd trades and multiple supply chains
- Complex contract structures

Large corporate businesses that deliver retrofit services do so mainly in the social housing sector where a contract is awarded to retrofit many houses. In the short term this model would struggle to deliver retrofit to individual properties in a time effective way since properties being subjected to retrofit may not being close proximity to one another, in addition the variety of interventions is highly likely be much greater.

To be successful in the private owner occupier market the large corporate model will need to be modified to include marketing and sales. In current form a single sale or contract will deliver several hundred properties for retrofit, most of which will be very similar in construction and layout, this will mean little variety in technical solution and in customisation of finish or fit out.

The main requirement from large corporate deliverers of retrofit, and indeed smaller ones, is to carrying out retrofit on owner occupied property is there is not the same certainty of payment as enjoyed when delivering into government backed schemes or working with local authorities / housing associations. Confidence in the stability of any market stimulus is also a consideration when assessing whether to invest in a new sector. This has been reinforced with the recent rapidly introduced change to the Feed-In Tariff for Solar PV energy generation. The third obstacle is the uncertainty where the liability will rest when unforeseen problems arise in future since lifetime of products installed is around, or in excess of 25 years. Insuring against possible eventualities is seen as an issue.

The National Contractor currently struggles to compete with smaller organisation on price as they incur higher overhead costs, trade labour is sub contracted which in turn adds multiple levels of margin and complex contract arrangements. This can be offset when economies of scale come in to play, this is not present in house by house retrofit but this model may still be attractive for large landlords or large housing estates.

9.3 NATIONAL / RMI SPECIALIST COMPANY.

Headline Attributes

- Delivery mainly to Social Housing
- Delivery of schemes subsidised by CERT and CESP
- Delivery Trade Labour is Directly Employed
- Silo'd trades and multiple supply chains
- Mostly One Sale = One Home

There are a number of companies in existence delivering retrofit within the UK. These have formed mainly to deliver initiatives such as CERT, as such they specialise in delivering the interventions attracting subsidies. Customer base is mostly centred on social housing. During work for this report it was revealed that there is considerable concern about the future for them as CERT is drawing to an end and the Green Deal / ECO replacements have yet to be published in detail. This uncertainty has led to

different approaches; wait and see; or to look for retrofit opportunities through marketing activities and performing thermal imaging surveys on properties speculatively. Of the companies contacted for this report, training for retrofitters is carried out in-company with a preference for carrying out all retrofit works with fully employed labour rather than sub-contractors. This is in order to control quality and costs.

9.4 National RMI Retail Company

Headline Attributes

- Delivery Mostly to Owner Occupiers
- Delivery Trade Labour is Generally Directly Employed (some organisations formerly used self-employed labour, but brought in-house to improve quality and accountability)
- One Sale = One House
- Silo'd Trades and multiple supply chains
- Starting to include a number of measures for energy efficiency and renewables

These companies have an existing private customer base and typically carry out 3 levels of retrofit works over a number of years for clients. These works are generally less than £10,000 in value but this illustrates brand loyalty and a desire to continue to improve the home. As shown in the table below the customer base is mainly owner occupiers, this is a key difference from the National specialist. This model is able to migrate to a multi skilled delivery team for installation but the supply chain for products is likely to remain trade and product based unless a move towards the least wasteful supply chain idea is made

9.5 Scalable unit model

Headline Attributes

- Small Multi-Skilled delivery teams with clearly defined geographic regions allocated
- Standardised work and products
- Simple, effective and integrated supply chain
- One sale = one house

The focus for this report is the scalable unit since this is focussed on the single dwelling rather than batches of houses which is more common in today's retrofit

market. This model does not currently exist but it is widely accepted that this is a quick method to increase capacity and develop national coverage.

The approach envisaged is a "Packaged Business". Where a leading organisation develops a brand and product offering and provides all of the training, equipment, back-up and support needed to give the scalable unit a good chance to attract and deliver business. Risks associated with new businesses can be minimised through training, advice and support together with a recognised brand, advertising and market development

The capital required to sale this model is low once the product development and base infrastructure are in place. On-going research and development and advice / support are provided as part of the support structure. The scalable unit will also enjoy the benefits of scale through the supporting brand.

Entry into retrofit delivery would require relevant training in:

- The operation of the business license
- Business administration, registering a company, employment, Tax and VAT, insurance, invoicing and credit control etc.
- Training in the relevant skills to install retrofit measures
- Provision of tools, equipment and plant

Key to the success of this model is establishing the quality standards and control mechanisms necessary to provide excellent customer satisfaction and protect / build the brand. The local delivery element is vital to attract customers looking for local companies who have credibility in the surrounding area and can be verified by friends, family, neighbours and colleagues. This is considered to be an important requirement across most customer segments

9.6 HYBRID MODEL

Headline Attributes

- Could achieve the least wasteful supply chain
- Delivery arm could be scalable unit
- Energy companies have data to target customers particularly those in fuel poverty ,They are motivated to save carbon and could provide routes to funding
- Infrastructure companies could have access to owners of many properties, eg. MOD, Church of England, National Trust.

The hybrid model could be attractive in a collaborative framework used to deliver the "Least Wasteful" supply chain described earlier in this report. The corporate entity owning the retrofit factory would manage risk resulting in a lower entry cost to the smaller contractors / delivery units delivering the retrofit. The down side of this model is the time taken to establish contract structures together with team working / ownership to continuously improve project delivery. There are various aspects of the supply chain that could be attractive for large corporations to own. These could be in product manufacture or customisation, kitting, or in logistic and waste processing.

Two models are considered here.

- Energy Company Hybrid
- Facilities Management Company Hybrid

Energy companies are obliged to facilitate reduction in carbon emissions through initiatives such as CERT and ECO. They also have access to customer data including location, energy consumption and credit rating. This easy access to data could be a driver to exploit market and offer an effective marketing tool. Energy companies could also provide finance for retrofit works as part of the overall package. The delivery end of the supply chain could be organised as suggested in the supply chain configuration section of this report.

Facilities management companies such as those carrying out major project works for the Ministry of Defence, the Church of England etc. could use their resources to enter the market to deliver retrofit to domestic housing leveraging their existing relationships with Government and other institutions.

Challenges here are the margins that these larger businesses expect to enjoy. A large premium for a major brand may tip the affordability balance the wrong way.

9.7 DIY

As the processes of survey and installation developed, it became clear that long term durability of the packages and high levels of quality in the detailing are required to deliver the requisite retrofit performance. It may become more difficult as technology and materials become more advanced (although the goal will be to make new products idiot proof). Therefore, it is unlikely that DIY installation will make up significant numbers of domestic retrofit works. Other drawbacks include the length of time taken to install without specialist skills, increased disruption; inability to obtain a performance warranty for products and so reducing the saleability of the property.

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Figure 3 Assessment of delivery models against house type / tenure and customer segment ***Which delivery model is most likely and suitable to deliver retrofit to each customer segment? And how could different models migrate and develop?***

	Property	Customer Group	Tenure	National Contractor	National Specialist	Retail RMI	Scaleable Unit/	Hybrid	Hybrid	DIY
	(rank)			Wates	Apollo / Mark	Anglian	Franchise	Energy Co	FM Co MOD	DIY
Property Type / Age	Pre 1919 Mid Terrace **(1)**	YS	**Social**	**HC**	**HC**	MF	*LV*	HF	HF	x
		Gg	*Private*	*L V*	L F	M F	H F	*LV*	*LV*	L F
		EE	*Private*	*L V*	L F	M F	H F	MF	HF	L F
	Pre 1919 Detached **(17)**	SR	OwnerO	*M V*	L F	**M C**	H F	MF	*LV*	**M C**
	Pre 1919 Converted Flat **(11)**	GG	*Private*	*L V*	L F	M F	H F	*LV*	*LV*	M F
	1919-1944 Semi Detached **(2)**	MG	OwnerO	M F	M F	**H C**	H F	MF	LF	MF
		TR	OwnerO	M F	M F	**H C**	H F	HF	MF	L F
		UC	**Social**	**H C**	**H C**	L F	*L V*	HF	HF	X
		OE	OwnerO	M F	MF	**H C**	H F	MF	MF	L F
	1945-1964 Semi Detached **(3)**	UD	**Social**	**H C**	**H C**	M F	*L V*	HF	MF	X
		UC	**Social**	**H C**	**H C**	M F	*L V*	HF	MF	X
		SP	**Social**	**H C**	**H C**	M F	*L V*	HF	HF	X
		TR	OwnerO	M F	M F	**H C**	M F	MF	*MV*	L F
		OE	OwnerO	M F	MF	**H C**	M F	MF	*LV*	L F
	1965-1980 Detached **(8+10)**	OE	OwnerO	M F	H F	**H C**	M F	HF	*LV*	L F
		SP	**Social**	**H C**	**H C**	M F	*L V*	HF	HF	X
	1965-1980 Purpose Built Flat **(6)**	YS	**Social**	**H C**	**H C**	M F	*L V*	HF	HF	X
	Post 1980 Detached **(4)**	SR	OwnerO	*M V*	M F	**M C**	H F	*HV*	LF	**M C**
		MG	OwnerO	M F	M F	**H C**	H F	*MV*	LF	MF
		EE	OwnerO	M F	M F	**M C**	M F	*MV*	LF	**M C**

	L Low Liklihood of volume			**C Current**						
	Medium			F Futre						
	High			*V Very Long Term*						
	x	Not considered - unlikely to take-up or does not apply								

10 Current Sales and Delivery Routes

The majority of solid wall insulation installations currently occur in the social housing sector where many properties are retrofitted together. Schemes such as these offer economies of scale, restricted variety and one client. The management of the tenant must clearly be a handled effectively and sympathetically but the demands on this situation on choice, quality and flexibility will be simpler to meet. In addition one sale = many properties whereas in the private owner occupier market one sale = one house

When asked about the current capacity to deliver whole house retrofit, organisations consider this to be commercially sensitive information. The consensus amongst companies is that doubling of existing capacity could easily be achieved; it is the coordination, control and site management that would be problematic. Existing trade

labour appears to be plentiful due to the downturn in construction as a result of the credit crunch and other factors; in addition labour from with the European Union is straightforward and could provide a source of competent trade skills.

The provision of appropriate training and accreditation must be considered to be a priority if delivery capacity is to grow to meet the required level which we have estimated to be 400,000 installations per annum by 2015. Training must cover the core competences required for retrofit which cover the three main headings of:

- Installation of dynamic measures – eg. primary heat source, MVHR, wiring etc.
- Installation of Static measures – eg. insulation
- Precise working and finishing – following precise instructions, trim to fit, observing product limitations

There is significant overlap between the main competence headings listed above, these will be explored in detail in later reports.

Should existing companies commence mass retrofit, any increase in capacity will probably be through existing pool labour and training provided by the companies themselves. Further increases in capacity would require capital outlay and an available supply of trained and certified labour to meet the needs of the market. Since this training / qualification system does not yet exist we must expect a time lag between its creation and the first available people through the training.

11 Retrofit Demand

To achieve the retrofit of 26million homes for energy efficiency by 2050 capacity will need to ramp-up to at least 500,000 per annum is. The first 100,00 of delivery capability exists now but does not fully meet the requirements of the value propositions developed for mass appeal. Organisations, delivery teams, materials and technical solutions all need to be improved to meet these. Future delivery capability will need to be built now to achieve the scale required to achieve the above objectives.

11.1 Models

It is possible for companies entering the market early to capture the market and influence its direction and velocity.

There are 3 possible consequences of early building of demand

- Companies go head to head with different branded solutions and fight it out – this is analogous analogy to Betamax, VHS, Umatic and Video2000 during

the 1980's With no clear standard each format fought for market space with VHS finally winning out due to this becoming the standard for video rental services but not being the best technical or most cost effective solution

- Companies cooperate and work to their strengths with standardised solutions – The analogy here is the standard approach taken in the IT industry with the Bluetooth standard. With a clear standard this has created the idea that with the common interface different solutions may be developed around a standard introduced and controlled within its own industry
- A solution imposed on the industry such as Building Regulation. – The result has been to find ways around this regulation as it is seen as cumbersome and slow to change as new methods, processes and materials arrive.

Clearly an industry defined and controlled standard would be the ideal. Businesses entering the market early would clearly be in an advantageous position to influence retrofit standards.

11.2 Current Capacity to Deliver

In the report for WP 4.1 an estimate of capacity within the UK to carry out solid wall insulation was made of 100,000 per annum. Research is in progress by the UK department of Energy and Climate Change which is assessing current capacity and how quickly this may be built to deliver energy efficiency retrofit. Results of this research will not be complete until the end of March 2012. And we have been unable to access data being fed into this process from associations and trade bodies. Work carried out here will report capacity based on estimates made in cooperation with the supply chain members who have been involved with this project. It should be noted however that there is the risk that companies have made the assumption that trade labour availability is not a problem but they will all be pulling from the same labour pool resulting in shortages in the short term.

11.3 Increasing Delivery Capacity

The simplest way to build capacity would be for each current installer to increase capacity to deliver more retrofits. There are several problems to overcome with this approach. As most existing companies have been installing retrofit measures as part of CERT or the decent homes programme work has been funded and commercial sales activity has not been required to secure the business. In addition most work has been carried out in the social housing market; work carried out in the private owner occupier sector has been restricted mainly to loft and cavity wall insulation. Mass refurbishment of owner occupier housing will require a different approach.

A major difference for mass refurbishment for this sector is securing the sale. The entry point could be via direct marketing or via the energy companies. Either way it will be necessary for a trusted entity to deliver the retrofit, in an agreed time window to the correct technical and aesthetic quality and to meet the technical specification for the embodied products. For this reason it is likely that in the short term companies operating nationally in the private home in the RMI market are more likely to build market share more quickly.

11.4 Building on existing capacity

Existing businesses surveyed have seen a down turn in sales of windows, doors and solid wall insulation over the past 5 years as a result of the credit crunch. There is the view that there are many trained fitters of replacement windows, doors and solid wall, cavity wall and roof insulation to allow most businesses to increase capacity quickly with a minimum of retraining. Primary heat source is not included in this however 118,000 boilers were replaced under the Boiler Scrapage Scheme over a 9 month period. Some 50,000 installers were directly involved in the scheme so it appears that there is capacity in some volume on which to build. (Source the Energy Saving Trust)

11.5 New Start-up companies

If demand is abundant for retrofit then new companies could, with the required expertise, equipment and funding, enter the market. A simple method to ease the forming of new businesses is to develop the idea of a retrofit franchise where a trusted brand develops a business supplying retrofit equipment, training and components, then sells the rights to geographic areas to individuals keen to start a business. Areas or territories sold are usually specified by postcode.

Alternatively building or heating companies may expand their range of services to include whole house retrofit. Existing businesses that have a good reputation are likely to gain the trust of householders in their local area, this s seen as important by most customer segments as reported by WP.5.4

A third possibility is that new businesses enter the market using the strength of their brand with consumers, the new supply chain models presented in this report could provide the vehicle for this strategy to be deployed.

12 Training and Accreditation

12.1 TRAINING

To increase the capacity for whole house retrofit it will be necessary to fully understand the range of skills needed and to construct a training and certification system to provide a competent workforce.

The skills needed range from the trade functions which would traditionally been

- Surveyor
- Heating and Plumbing
- Electrician
- Carpentry / Joinery
- General building
- Plastering / rendering
- Labouring

There is a mix of skills needed from all of these general trades for whole house retrofit. The following sections of this report suggest a general programme of work delivered by a small autonomous team delivering whole house retrofit. This covers all of the tasks needed and illustrated how the skills from the existing trades could be embodied within the team. Specialist training and certification will need to be developed to deliver the needs of this emerging industry. As noted in the report for Work Package 4.2 the existing trade based system reinforces the ineffective silo based supply which limits flexibility and effectiveness through duplication at every juncture

To cover the whole of the England, Wales, Scotland and Ireland it is estimated that approximately 60 training centres will be needed. This estimate has been made with input from Construction Skills, training agencies such as the Building Skill s academy and construction companies carrying out their own in house training. There are existing training modules covering all of the current retrofit works planned, these will however need to be repackaged as a minimum to reflect the "small specialist retrofit team approach" suggested here to maximise effectiveness on site, and minimise disruption and time taken.

To enable the retrofit industry to expand, appropriate training schemes will need to be developed and deployed. The majority of skills / competence training requirements are covered by existing courses these are linked to qualifications available from the following 5 main bodies:

- City and Guilds
- Awarding Body for the Built Environment
- EMTA Awards
- Construction Awards Alliance
- Edexel

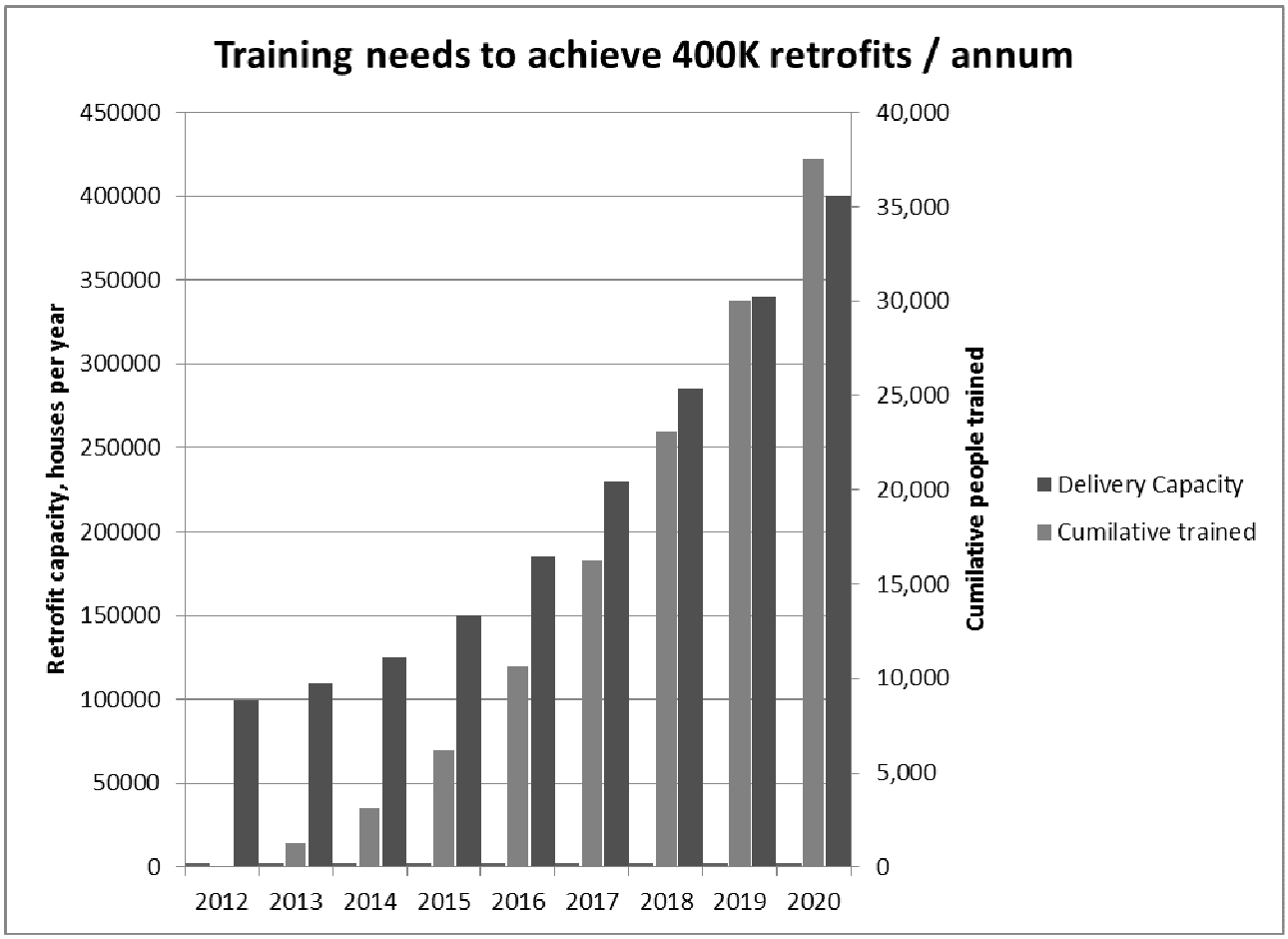
The above cover all aspects in the built environment including activities relating to domestic retrofit. Most recently qualifications have been introduced to cover solar PV and solar thermal installation and commissioning. It has been demonstrated that new training schemes and qualifications may be developed and introduced quickly. The challenge remains to centralise feedback to continually improve and update courses, examinations and assessments to include developing best practice and the introduction of new products. It is highly likely that new methods will emerge to deal with the plethora of problems that domestic refurbishment will deliver.

Due to the nature of retrofit works unless strict quality guidelines are followed in selection of the correct materials and the correct installation, poor quality control may not be immediately obvious. Future problems with condensation and poor sealing of insulation, and poor vapour barrier sealing may take years to become apparent.

Through discussions with installers of retrofit measures there are several different routes to obtaining qualifications relating to retrofit works.

- Informal "on the job training"
- Formal training with a mix of classroom and on site activity.
- "Off the job training" a mixture of classroom theory and practical application. This may take place at the employers premises or at a specialist college / training centre.
- Continual professional development which could be lined to NVQ qualifications
- On Line Learning, where curses are available

For start-up companies where a great deal of training is needed intensive courses are required, these must lead to either a recognised qualification or entry to a recognised body providing accreditation in retrofit. It is estimated that a period of one year is needed to develop the competence profile, supporting training framework and underpinning processes. The required time for off line training for retrofit within companies training their own fitters is currently between 6 and 16 weeks. This is predominately off the job training. An assessment has been made of the time taken to train retrofitters to achieve approximately 400,000 domestic retrofits per annum.



Note that the existing capacity of 100,000 homes is using existing companies plus existing trade labour and processes.

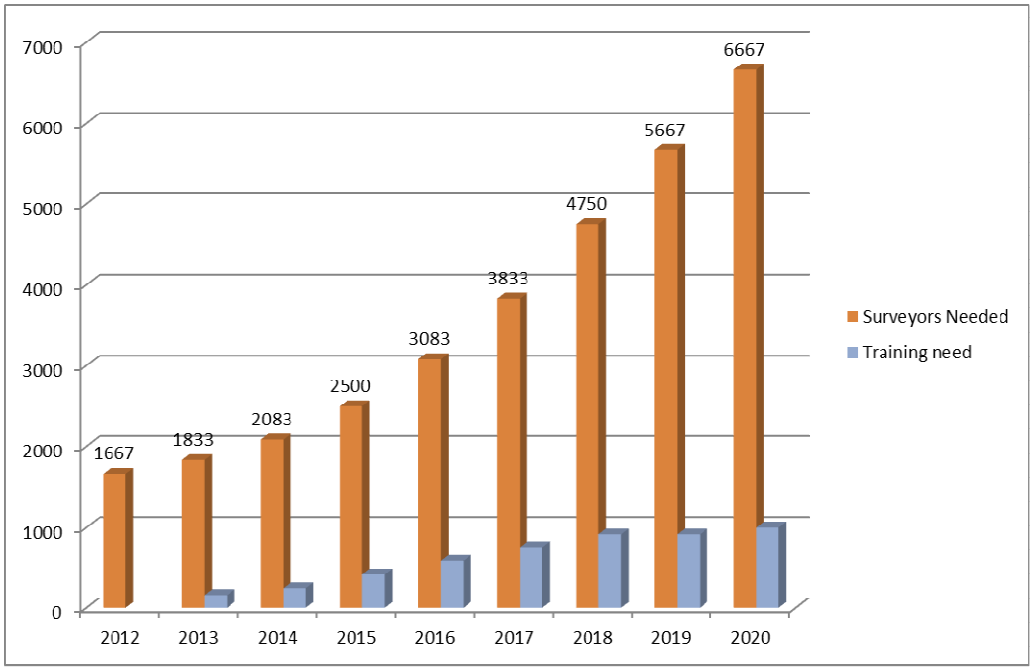
To achieve the above a sensible rate of training is suggested in the table below

Year	Retrofitters trained per year
2012	
2013	1,250
2014	1,875
2015	3,125
2016	4,375
2017	5,625
2018	6,875
2019	6,875
2020	7,500

The basis of the above numbers is that teams of 5 retrofitters carry out 40 retrofits per year. Therefore the required number of retrofitters is 400,000 / 40 *5 =50,000 assuming no spare capacity. Assuming existing capacity is 100K properties per year

the total number of people that need to be trained to deliver the 400K per year is 37,500. The work presented in the following section of this report details the installation programme and skills required to retrofit properties of different types and the time taken using materials, methods and manpower used today. These will be challenged as the project progresses. In summary the programme where the greatest labour requirement is shown requires 5 people working on site illustrating that the team of 5 is viable.

Chart Showing number of Surveyors needed and training needs over time



The above assumes the required man hours of the survey stated in the Survey Process section of this document. This allows for more surveys than demand allowing for deferred or cancelled planned installations.

Clearly, in addition to the retrofit teams back office support, design, procurement, planning and supervision will be needed.

An estimate of employment numbers needed to support whole house retrofit is

12.2 Accreditation

It is desirable to continue the Competent Person Scheme which was started by the Government to allow retrofitters to certify that their work complies with Building Regulations without the need to involve a building control body. The scope of the scheme will need to be expanded or modified to cover installation of multiple products, windows, primary heat source, and solid wall insulation. This will be studied in depth after the skills required for retrofit have been fully worked through;

this is being developed as part of the retrofit programme planning activity which is taking part for this report. The value of accreditation must be tested with work package 5, customer engagement to understand what value customers place upon accreditation and whether in itself it adds to the trust customers place within a delivery organisation.

There are 3 requirements to fulfil with accreditation for retrofit

- To provide a robust system to give confidence to customers that the organisation is competent to carry out the scope of work
- To ensure that insurance backed warranties are provided for all works carried out
- To provide a means of redress to customer complaints

As detailed in work package 5 reports, key elements to deliver are Trust and Certainty that work will be carried out to the stated schedule, cost and quality standards. Accreditation is a means to demonstrate that installers carry out work to agreed quality standards.

The main competent person schemes in operation are

- Gas Safe – covering plumbing, ventilation, heating and electrical
- Association of Plumbing and Heating Contractors – covering Oils and solid fuel equipment, plumbing and waste water and water regulations, and energy efficiency.
- Building Engineering Services.- Covering Plumbing, heating and energy efficiency.
- FENSA glass and glazing federation.
- National Association of Professional Inspectors and Testers – Covering Plumbing and heating, electrical and ventilation
- Heating Equipment Testing and Approval Scheme- Covering Solid fuel appliances and associated equipment.

Accreditation bodies

There are other accreditation schemes specifically relating to retrofit interventions.

- Glass and Glazing
  - FENSA – glass and glazing federation
- Cavity Wall insulation
  - National Insulation Association

    - British Board of Agrement
    - Cavity Insulation Guarantee Scheme
- Solid wall insulation
    - Insulated Render and Cladding Association
- Construction Skills Certification
    - Covering many individual skills and techniques
- National Inspection council for Electrical Installation Contracting
- Heating and Ventilation Contractors Association
- STROMA.
    - Building sustainability and compliance
- Micro-generation Certification Scheme
    - Solar Hot Water and Solar PV
    - Micro Wind and Hydro
    - Biomass
    - Heat Pumps
    - Micro CHP and Renewable CHP
    - Fuel Cells

Through discussions with the Construction Skills Council and the Department For Climate Change it is apparent that retrofit is an important subject along with understanding the skills and accreditation systems underpinning domestic retrofit. This will become an important part of the industries strategy for building a capable supply chain to deliver retrofit to the UK's 26 million existing homes, this is the subject of major work leading up to the launch of the UK Green Deal and the energy company obligation.

It is becoming clear that there is a danger that the current systems of training, qualification and accreditation could reinforce the trade silos making it difficult to move towards a more effective and less wasteful supply chain solution for domestic retrofit. To break the current paradigm it will be necessary to train and qualify new tradespeople and surveyors to be able to effectively assess properties and to fit a range of retrofit measures to them. This will require a range of skills some of which are currently considered to be specialist.

It is recommended that a new accreditation scheme is developed covering all aspects of retrofit considered as part of this project. This will cover as a minimum:

- Retrofit Surveyor parts 1 and 2
- External and Internal wall insulation

- Roof insulation
- Primary heat source installation (to include Gas and Electrical systems)
- Replacement windows and doors (including secondary glazing and draught proofing)

13 The Value of Retrofit

This Section gives and initial qualitative assessment of potential Economic Value Added to UK economy based on considerations of:
- Energy Saved – valued using the DECC IAG tool
- Infrastructure investment avoided
- Employment
- Export Potential & Licencing

The objective here is to explore the basket of potential benefits and costs to the UK economy and seek review and comment from economists and others who we hope will challenge refine our assumptions and thinking.

13.1 Value of Reduced Energy Consumption

What might we save?

At the householder level the key interest is in payback of investment. Even so individuals are not all fully rational and will reject the 'maths' investing in things that will not payback, and rejecting simple changes which have multiple returns on investment. At the national level we need to ensure that the direction of travel for energy saving is correct, but that the rate of change is both sufficient and affordable.

The single dwelling plan has developed 2 levels of retrofit details (Basic whole house & Enhanced) and added a contrast to the Passivhaus standard.

These scenarios anticipate the following savings:

- Basic Packages 30%,
- Enhanced Packages 45%,
- Passivhaus Packages 70%

Assumptions:

- Typical 20MWh annual consumption (average is 24MWh but many outliers).

- Ramping-up from 2014
- 650,000 properties /yr by 2026
- All retrofits have a design life of at least 40yrs (replacement costs considered as maintenance rather than investment).
- 21M Homes by 2050

		Baseline	Basic Package	Enhanced Package	Passiv Haus
1	**Energy Use (total)**	20 MWh	14MWh	12MWh	6MWh
2	**Energy Saving Target (ave)**	0%	30%	40%	70%
3	**EVA DECC Energy Saving £bn**	N.P.V.	**£60.2**	**£79.3**	**£136.7**
4	**Retrofit Cost (Current)**		£18,000	£35,000	£60,000
5	**Target Cost**		£8,000	£15,000	£25,000
6	**Annual NPV Current cost £bn**		**-£5.4**	**-£12.0**	**-£20.6**
7	**Annual NPV @ Target cost £bn**		**-£0.9**	**-£3.2**	**-£5.2**
8	**Break even package cost**	N.P.V.	**£5,900**	**£7,850**	**£13,500**
9	**Peak annual Break Even investment £bn**		£3.8	£5.1	£8.8

This table shows a challenging picture for driving costs down to achieve break even for retrofitting UK housing stock.

The team anticipated that current retrofit costs would be unaffordable and had set stretching targets. Break even costs where retrofit has a zero NPV are a considerable further stretch, but it is not inconceivable to attain them in the medium term.

The following sections briefly consider other factors which might off-set the negative NPV while product and process improvement drives down costs.

13.2 Additional Disposable Income

If households are saving up to 70% of their energy bills; their disposable income will income will increase and be available to spend elsewhere.

Our hypotheses, for challenge, are that:

- On balance VAT take for the spending will be higher than the 5% which domestic energy attracts.
- More likely to be on items with a UK Value add (services, food and, consumer goods) than imported energy which they will replace.

For those who have had to borrow to make the savings, which may only become cost neutral over time, we need a model.

13.3 Substitution for Maintenance and Repair

UK housing stock on average is not in good condition. With a national programme of energy upgrade we will be stabilising or improving the stock.

This will offset the pure payback issues of retrofit and, once the compelling value propositions are created, the work will be done for aesthetic as much as energy improvement.

13.4 Avoided Infrastructure

The bulk of savings in the next 20years will be reduced gas consumption, rather than electrical energy. This reduces dependency on imported gas and may have an impact on reduced gas terminal infrastructure. The more significant avoidance is if the UK shifts from Gas to Electric heating with renewable or other carbon free generation and as a result needs to fund a massive increase in distribution capacity

13.5 Construction Turnover & Employment

Peak retrofit turnover is likely to be between £5bn and £10bn equivalent which is less than 10% of UK construction turnover and so sounds achievable. The numbers employed (totalling around 50,000 directly) are not going to shrink the unemployment statistics very far, but the swing will have an impact. We also need to be careful that those shifting from other forms of construction (cavity wall insulation) are not double counted.

The argument has also been made to the team that making the retrofit process more effective will reduce numbers employed and tax take, so is therefore a step in the wrong direction.

13.6 Upstream Supply

There will certainly be an analogous impact upstream if increased volumes of material are supplied. Some will be substitutional for general building work, and our intention is to have a much more material efficient supply than construction in general.

Simplicity is key, but there is a likelihood that there will be an increase in the use of higher technology products (phase change materials, sophisticated controls, vacuum glazing & insulation). These have higher added value and a much higher export potential than construction commodities. The corollary is that if other nations develop the leading materials and products they will enjoy the additional value add rather than UK plc. Our challenge is to stay near the top of the following hierarchy:

- UK Design, manufacture & export products and services.

- UK Design & export services, products made locally under licence.
- UK Design and overseas manufacture under licence – reimported to UK
- Fully imported design and manufacture.

13.7 Summary

The above are points are all presented for challenge and debate. We are mindful of a discussion with a DECC economist to avoid the temptation to justify decisions based potential growth in employment, export or GDP which have no causal link and tend not to materialise.

The Consortium's focus will remain to develop compelling value propositions which will attract consumers on their merits. However, we welcome comments on where additional benefits may lie which could be used to offset the improvement curve.

14 Conclusions and Next steps

14.1 Conclusions

From assessments made during this piece of work supply of delivery capacity and material / products for whole house retrofit are sufficient for 100,000 houses per annum with a stretch capacity of around 200,000 houses per annum. Existing training course modules are available covering virtually all aspects of retrofit although not necessarily in a useable configuration for mass roll out of retrofit.

The biggest challenges remain

- The survey and development of skills, methods and tools to decrease time taken and invasive works needed to minimise risk during installation
- Supply of innovative new products and thinner insulation to overcome for example problems of insulating window revels, small eaves overhang
- Achieving and maintaining quality of service and results for retrofit.

In the report WP 4. 1 it was suggested that a single stage survey was required. It is suggested here that there are drawbacks with this approach and a 2 stage process may be preferable. If there are 2 survey visits the first can be used to gather data for the design, costing and programming of a retrofit whilst limiting the time taken and the cost in advance of a sale being made. The second survey visit would collect details needed for manufacturing of component parts and details of the condition of

the property to provide cost certainty. Further details of this approach are in section 7 of this document

As work progresses in designing a process for installation of the retrofit measures greater clarity of the challenges is being achieved; the programme offered within section 8 of this report details the programme of works for retrofit of the house types used in WP 3.4 and confirms that the speed requirements of the value propositions developed earlier can be achieved.

New challenges have come to light such as:

- Need for thinner insulation materials to deal with window and door reveals
- New products desirable to reduce time on site
- Dealing effectively with waste from site
- Requirement for flexible boiler performance
- A proposed phased installation plan and the need for flexible funding
    - The approach taken in work package 3 is to specify a basic and a best practice installation. Additional "value adding" measures such a replacement kitchens and bathrooms / loft conversions are also considered.
- Building effective and affordable accreditation systems recognised and trusted by customers
- Managing the long term liabilities arising from retrofit

Work undertaken reviewing supply existing chain players has revealed possible new models of financing retrofit works / product purchase such as renting / leasing products with service contracts.

When working the survey it was revealed that the output data may be of considerable value to other organisations in addition to the retrofit company. Confirmation of house type, condition, tenure, energy performance together with specific product data will all be available for use independently or in planning future service offerings or allowing replacement parts / products to be made available without returning to the property to "measure up". There is a possibility / requirement to provide simple replaceable modular components to facilitate the 2 stage retrofit process. For example:

- Boiler modules which permit the unit to be optimised for upgraded insulation allowing optimum efficiency to be maintained. These are becoming available with an efficient power range of the scale 10:1
- Exchangeable glass units for windows to facilitate simple upgrade
- Standardised replaceable hinges and locks for windows and doors

14.2 Next Steps

In the next work package workshops will be held to work with current suppliers of retrofit products and services to understand the precise standard work needed for survey and installation and the commercial infrastructure required to support the retrofit organisation. This will include a volumetric assessment of products and supplies required for retrofitting homes and processing waste generated and the logistics associated with material movements. This work will include special requirements identified in Work Package 5 where value delivery systems need to customise solutions for different customer segments. Further refinement will also be made to the retrofit plans for the different house types modelled in this report.

The supply chain models developed will be tested with current players in retrofit and likely new entrants. Further detail will be developed for retrofit survey and installation skills, and the through life process studied in depth.

A strategy for retrofit and housing data is needed as this will be of commercial value. Routes for exploitation and the impacts of data protection legislation will be explored in WP4.4

Appendix A: Estimate of Product Volumes

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Appendix B: Installation Programmes

1919-1944 Semi.xlsx

1945-1964 Semi.xlsx

1965-1980 Bungalow.xlsx

1965-1980 Detached.xlsx

1965-1980 purpose built low rise flat.xlsx

Post 1980 Detached.xlsx

Pre 1919 Detached.xlsx

Pre 1919 Mid Terrace.xlsx

Appendix C: Stakeholder Interviews

Suply chain review interviews.docx

Supply Chain Interviews.docx