Programme Area: Buildings

Project: Building Supply Chain for Mass Refurbishment of Houses

Title: Detailed supply chain workshop

Abstract:

Please note this report was produced in 2011/2012 and its contents may be out of date. This deliverable is number 5 of 8 in Work Package 4. The report builds on the previous Target Retrofit Supply Chain Scenarios report (WP4.3) to presents detailed plans for delivery of mass
scale whole house retrofit. This covers the survey and installation processes, the cost of retrofitting the most common property types in the UK and how cost is built up. In addition a market take up
hypothesis has been generated based on which customer segments will take up retrofit first; this allowed an estimate of regional coverage for retrofit capacity (manpower, materials and competencies) to be made. This has been dependent on the building stock modelling functionality developed in Work Package 2 of the project.

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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Detailed Supply Chain Workshop

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Contents:

1 Executive Summary

This work package deliverable builds on the previous Target Retrofit Supply Chain Scenarios report (WP4.3) and presents detailed plans for delivery of mass scale whole house retrofit. This covers the survey and installation processes, the cost of retrofitting the most common property types in the UK and how cost is built up.

Further study of the Survey process has reduced planned time to survey the most difficult house in detail (the second stage survey) type from 22 man hours to 8. There is scope to reduce this further but with 2 people this now delivers the required value proposition time of 4 hours on site work. The workshops held on the Survey process focussed on the data and individual tasks required from a survey progressing to specifying the competency and knowledge needed by the surveyor/s to provide a robust process, in addition the idea of using a member of the delivery team to carry out the survey is proposed.

The installation process has been planned with attention to the sequencing of retrofit activities and the competencies needed; the clear objective is to reduce the labour content of the retrofit together with eliminating waste within the supply chain to minimise cost. The most difficult property is projected to take 10 elapsed days to complete with a team of 4 poly competent retrofitters, with all programmes there are sufficient time slots where the lead retrofitter could leave site to carry out survey work on other properties, this leads to the clear advantage of continuity of personnel for retrofit from the householders perspective and giving ownership to the lead retrofitter.

An objective of this report is to present clear understanding of the cost of retrofit to the level of how material costs are built up. There has however been significant resistance from within the supply chain in allowing us access to cost information, this is dealt with in the section 6 of this report on costs but this leaves further work to be done to increase our understanding of the distribution of cost in the existing supply chain and how this may be reduced using different configurations

of supply, consolidation and delivery to site. Assumptions have been made on how these costs are built up and how these may be minimised; these assumptions are explained and will be tested as the project progresses.

In addition to the work carried out on process development and costs the stock model created in work packages 1 and 2 have been used to build up a picture of where the target house types are situated within the UK and what the density is by region and which customer segments live in them. A market take up hypothesis has been generated based on which customer segments will take up retrofit first; this allowed an estimate of regional coverage for retrofit capacity (manpower, materials and competencies) to be made.

In assessing the number of properties to be retrofitted over time, we have assumed that the social sector will continue to be served as it is now by large contractors who will seek to improve their delivery methods. Private landlords are likely to be encouraged to retrofit their properties as delivery time decreases and costs fall.

Key Messages

- The 4hour *detailed survey* with 2 people is possible (even for the most difficult house) and there is scope to reduce this further.
- It has been shown to be possible to retrofit the two levels of intervention, Retro Fix and Retro Plus across the modelled house types in 10 elapsed days or less (depending on property size/ complexity and weather permitting) using a team of 4 poly-competent retrofitters.
- Increasing competencies will be vital to deliver retrofit brilliantly and at scale - new training systems are required to provide an up-skilling route for people wishing to enter the retrofit industry.
- New or simplified accreditation and warranty systems are needed for retrofit.

- Standard retrofit solutions will help generate efficiency gains and simplify the provision of materials.
- Progress has been made to understand how cost is built up within the supply chain but further work is needed to allow key players to share cost information.
- Retrofit cost of under £10,000 for most house types is feasible but challenging for most house types based on our understanding of how cost is built up within the supply chain. More specific cost data will be generated for common house archetypes; these will be presented in follow up reports for this work package.

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. This project is studying how to design and model effective retrofit solutions for retrofitting existing housing, how to engage customers to carry out the work, and how this can be delivered brilliantly and supported by government action / legislation and incentives

Only a fraction of 1% of our existing housing stock has been proven to have adequate thermal performance to meet the UK's energy targets. To meet our 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.

Work Package 7 – Impacts of Health and Safety

This report presents the specification for what is needed from the refurbishment supply chain for whole house retrofit for improved energy efficiency.

3 Approach

The objective of Deliverable 4.4 is to develop a supply chain specification for whole house retrofit covering a substantial proportion of house types found in the UK. (Supply chain is defined as a system of organizations, people, technology, activities, information and resources involved in moving a product or service from the supplier to the customer)

The work presented here includes the methods and competency required to deliver retrofit effectively and economically, the breakdown of cost and how this is built up.

3.1 THEORY

Right to left Thinking

In this report we continue with the design of the retrofit delivery process - *right to left*, starting with customer desires (right of page) and building back to design and materials (left); the result of this process is that thinking is not constrained by the current supply chain and new, more effective means of providing the customer with what they want can be revealed. A specification is then developed in terms of target performance, speed, quality, flexibility and cost.

This report is structured with a high level future state supply chain (right side) presented first, followed by detailed descriptions of each element of the supply chain in the sequence of delivery to the customer. The purpose of this is to allow the detailed descriptions to be understood in context and that the supply chain presented here has been designed *right to left*

The least wasteful supply chain model presented in the WP4.3 report is the most effective we can imagine using the *right to left* process and all models considered should be compared and contrasted against this to benchmark effectiveness of the supply chain. Conventional left to right thinking is constrained by what already exists, such as warehouses, plant and equipment, training systems etc.

These are usually legacies built for another purpose which do not work effectively when used away from their original intent or context. The *right to left* process allows truly unconstrained thinking to create innovative solutions.

The process used to develop the survey, installation processes are detailed in chapters 5 and 6 of this report.

Lean systems thinking

As in Work Package 4.3 lean systems thinking was used to develop the processes for whole house retrofit detailed in this report. Particular attention was paid to process areas where high Risk Priority Number scores (RPN) were calculated during earlier workshops; this allowed detailing survey and installation process steps to be designed maximising process robustness. Throughout the remainder of the project all developments will be contrasted against the "least Wasteful" supply chain developed in WP 4.3 with the objective of a supply chain capable of delivering retrofit free of waste, deviation delay and defects at minimum cost. Cost is a primary driver as identified in consumer research carried out in WP 5.4 and it is therefore an objective to reduce the time taken to retrofit and to minimise all costs in both the retrofit survey and installation. Target cost for retrofit as detailed in the WP4.3 report is £5,900 for a typical 1940-60 Semi-detached property.

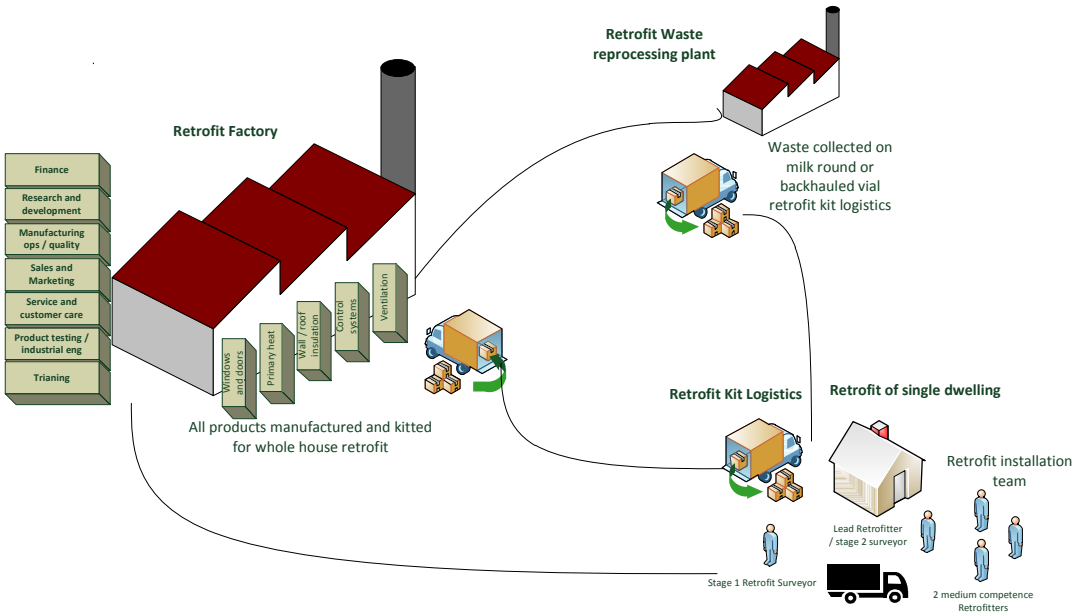
In parallel with the process design the task sequence is detailed and allocated to individuals in the retrofit team according to the competency level required to execute it; this covers the level 1 and 2 Survey and the Installation process. The "Poly-Competent" team of retrofitters proposed in the 4.3 Report is explored further and work programmes are presented for target house types for both the survey and installation processes. Standard retrofit measures have been developed in Work Package 3 and have been used as the basis for manpower plans, and labour and material costs presented here, the measures proposed for each house type and retrofit level is presented in appendix 1.

Data from the housing stock model was used to inform Which Customer Segments live in which house type and where these properties are located nationally. An assessment was then made of which segments are more likely to take up retrofit. The results of this were used to calculate national delivery capacity needs for manpower and materials.

4 Detailed Supply Chain Design

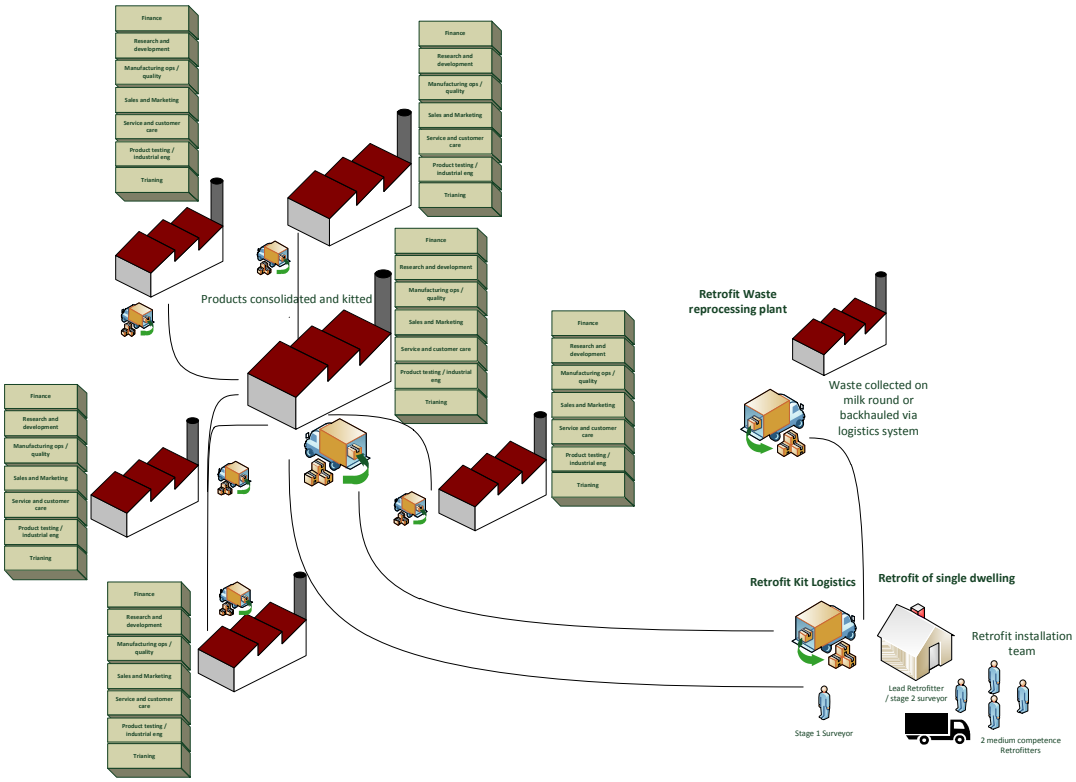
In previous reports a graphical illustration of the existing supply chain and other models were presented which led to the "least Wasteful supply chain model" which overcomes the inefficiencies of the current silo / trade based supply chain. In this report this work has been extended to include estimates of likely regional demand and supply chain capacity needed to deliver for both manpower and materials.

Figure 1 Least Wasteful supply chain configuration



The above diagram has been updated to show the delivery team of 4 and the "lead retrofitter" doubling as a 2nd stage surveyor. The stage 1 surveyor is the gateway to the sale and provides the customer with detailed information about retrofit.

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



As can be seen from the above, the *delivery end* of the supply chain is the same as for the least wasteful supply chain This model contains separate manufacturers for retrofit components and a consolidation centre where whole house retrofit kits are assembled ready for dispatch direct to site and illustrates how complexity increases with each move from the least wasteful model. In the short to medium term it is considered unlikely that all measures will be manufactured in the same factory space and shipped direct to site; therefore all costs and processes have been developed using the supply chain shown in figure 2.

4.1 Retrofit Packages

Two retrofit packages, Retro Fix and Retro Plus were developed in work package 3.4b for each of the main property types considered. These are detailed in Appendix 1. Both levels of intervention cover the same level of wall insulation and deliver loft & roof, door & window, air-tightness and heating system upgrades as appropriate. The costs are developed based on minimising material labour and overhead for each house type and package.

4.2 RETROFIT PROJECTED VOLUMES.

The volume information presented here is based on the premise that we need to grow a retrofit capability sufficient to retrofit a significant proportion of the UK's 26 million homes by 2050(particularly those built before1980). To achieve this capability we consider that building a capacity of 400,000 homes per annum by 2020 is achievable. Working back from this figure we suggest a trajectory to reach this target, refining this further by adding information on which house-types are occupied by the early-adopting segments identified in the Customer Value research carried out within Work Package 5.

The following graph shows the suggested growth rate for retrofit, excluding the current estimate of 100,000 homes per annum re-furbished by local authorities and social landlords. The stacked bars give an assessment of the likely phasing by customer segment (Detailed Customer Definitions in 5.5 – Customer Value Synthesis Report which included definitions of the segments which are age and affluence based). This aligns with proposal to **Focus Your Efforts** in marketing to the most receptive customer segments.

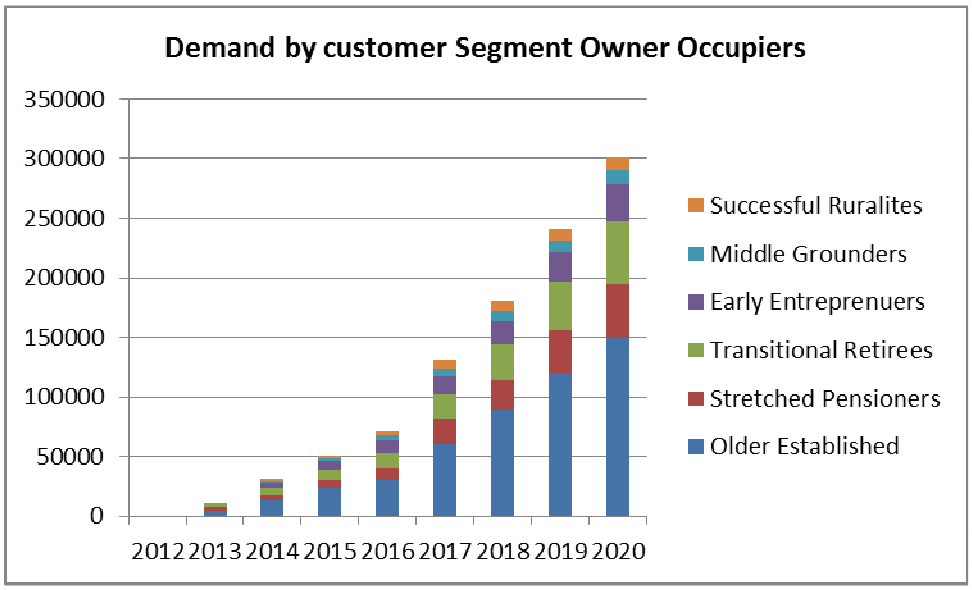


Table 4.1. Projected Additional UK demand for retrofit by customer segment.

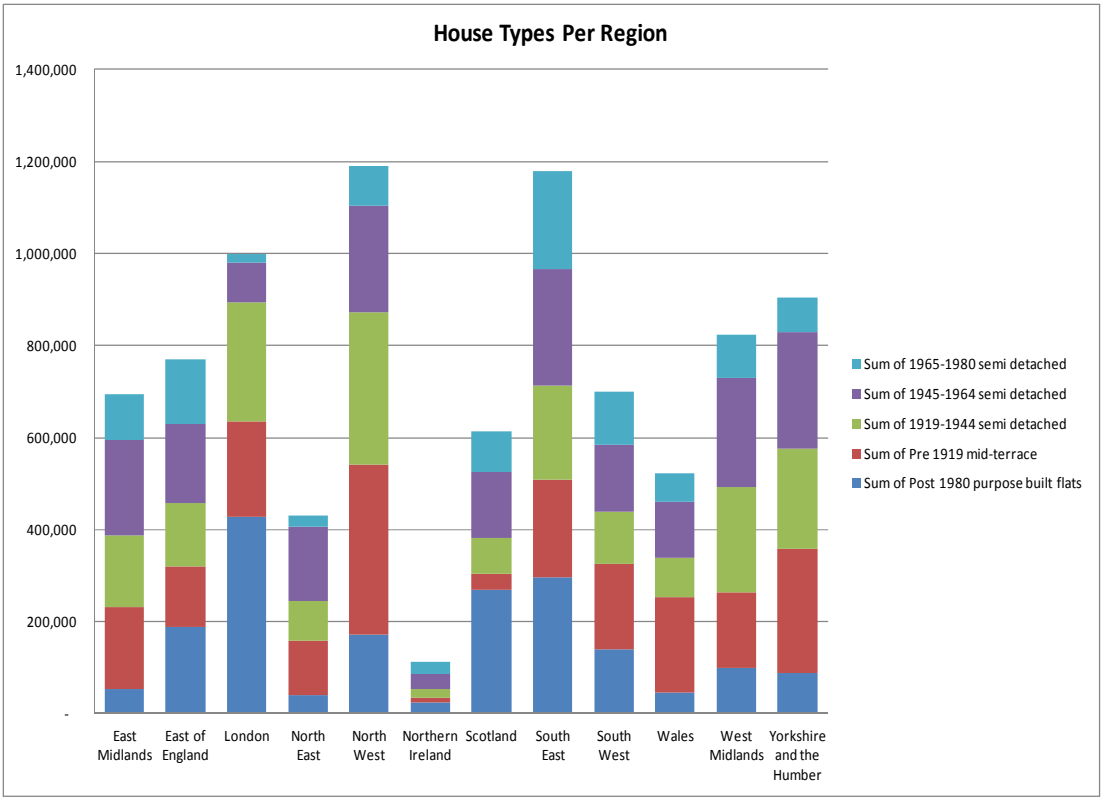


Table 4.2. Totals of each house type by region.

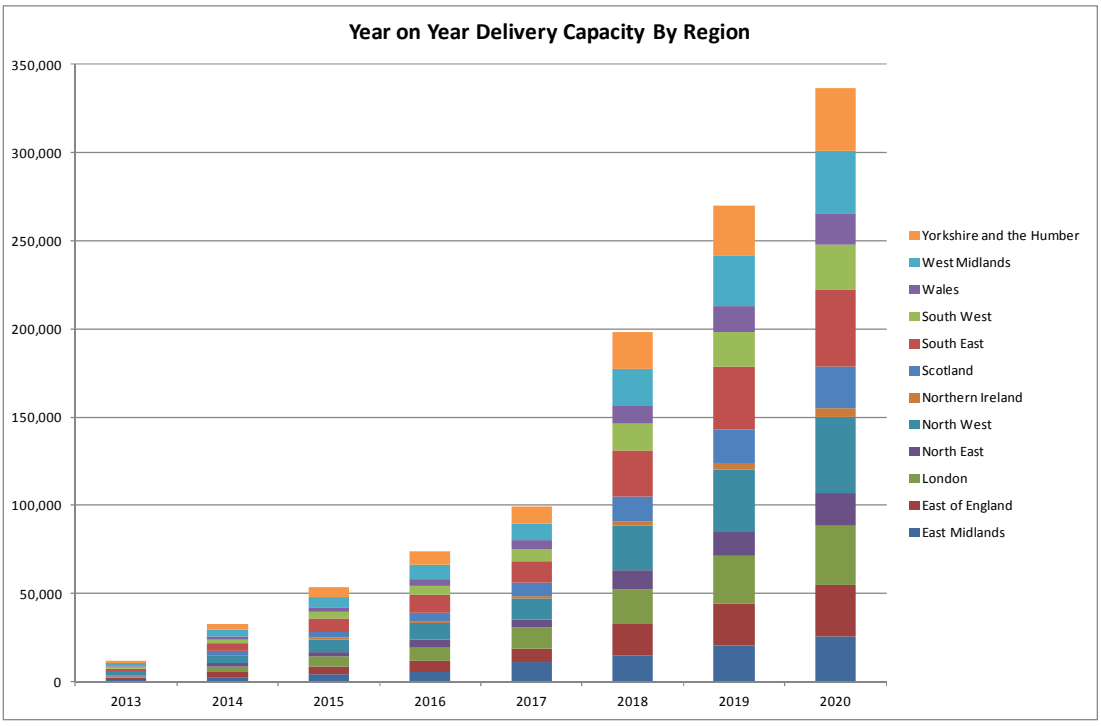
Table 4.2 above illustrates the numbers of each housing archetype by region. Each customer segment has been profiled to identify the two house-types they are most likely to inhabit. For example Early Entrepreneurs are profiled in Pre 1919 Mid Terrace and Post 1980 detached homes. A list of the customer segments by house types can be found on the "segment, house-type and tenure" tab in Appendix 1. Using the demand in table 4.1 and the house types by segment a profile of customer segmentation by region has been created

All data and the calculations relating to regional capacity is in appendix 13

Table 4.3 Customer Segmentation by Region.

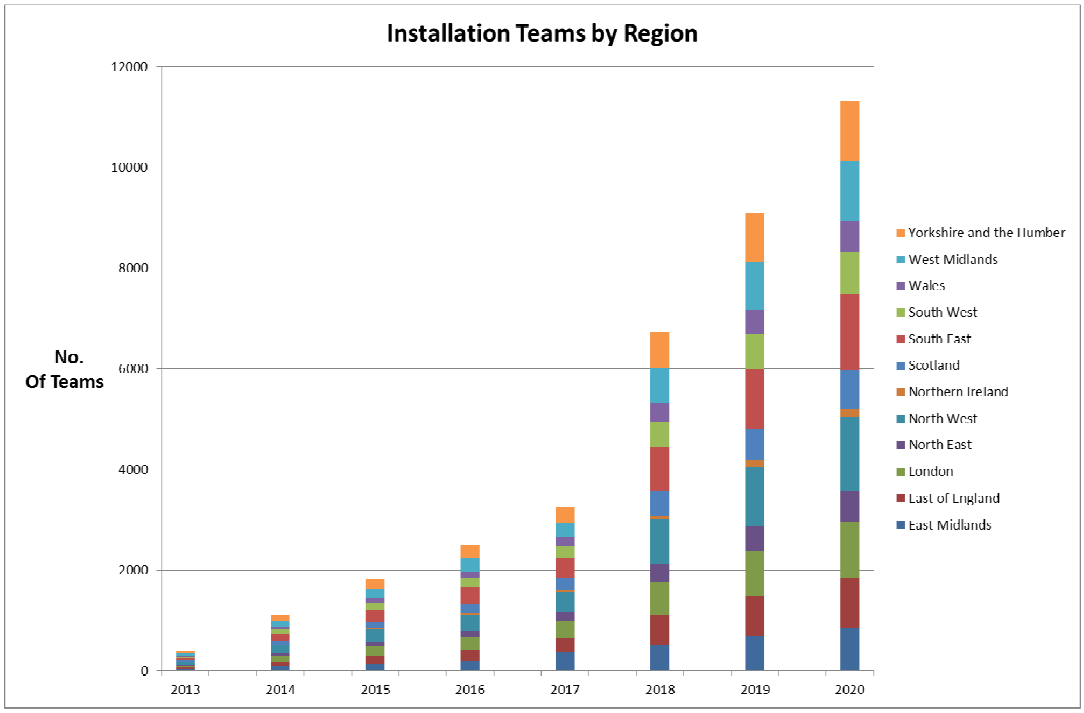
The data presented in Tables 4.1 and 4.3 was used to create the delivery capacity plan below.

Table 4.4. Delivery capacity plan by year by region



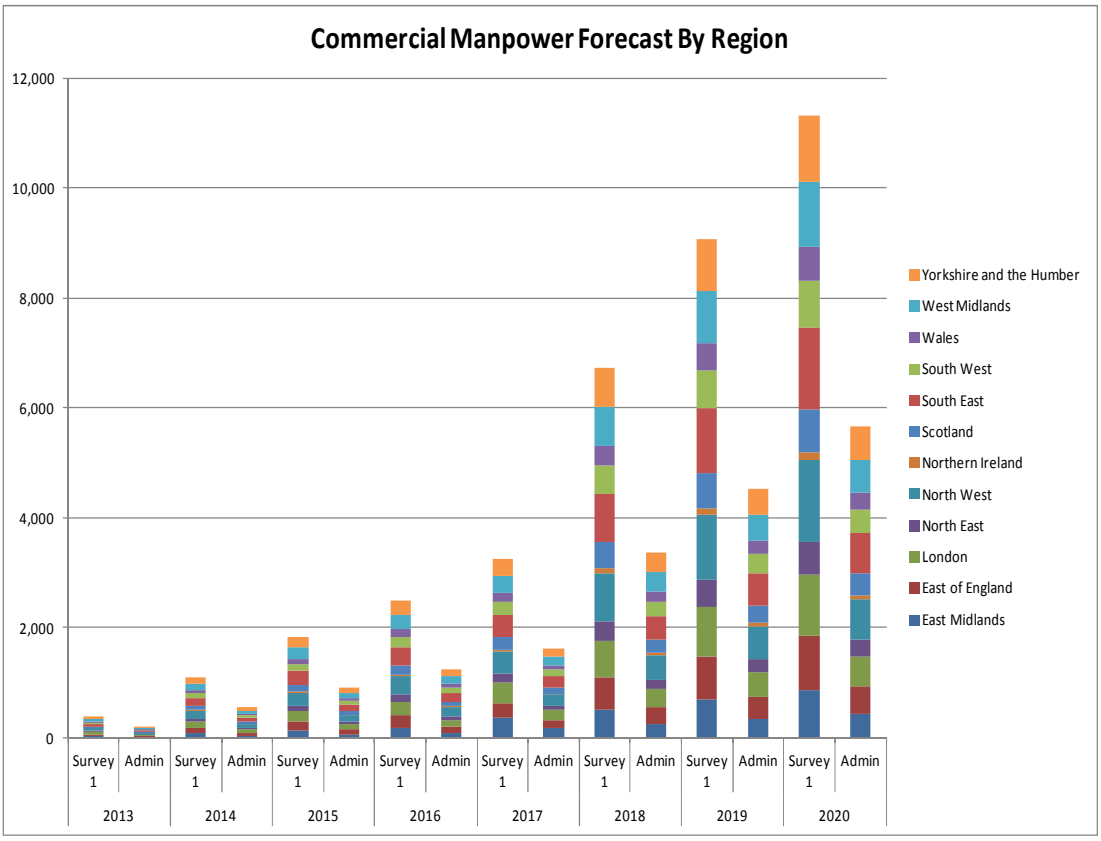
The table above forecasting regional demand has also been used to forecast labour and material requirements. Manpower requirements are split between commercial (Survey one / Sales and Admin) and the installation team.

Table 4.5. Installation Teams by Region.



As the number of installation teams is dependent on the house type being installed, the requirement by region has been calculated using the year on year delivery requirement in conjunction with customer segmentation for each region. The same approach has been used to forecast commercial manpower requirements.

Table 4.6. Commercial Manpower Requirements.



The above table shows the commercial manpower forecast split between stage 1 survey and back office admin support. In calculating a requirement for Stage 1 Survey manpower an assumption of 1 stage 1 surveyor will service 1 installation team has been made. The maximum survey time for stage 1 survey is predicted at 4 hrs. As the small scalable units consisting of poly competent teams are focused locally it is anticipated that the stage 1 surveyor will be able to perform up to 2 surveys a day and 1 per day on average across a year. This would give each stage 1 surveyor a theoretical capacity of 200 surveys per year. The annual installation requirement per team is 35 allowing for a conversion rate of up to 1 successful survey for every 5 completed. The actual conversion rate will be heavily linked to the quality and relevance of the Retrofit Packages to the customer in line with relevant and affordable finance packages.

For Admin Support an assumption has been made that 1 admin person can support 2 installation teams. The commercial manpower requirement therefore has been calculated based on the anticipated installation capacity as illustrated in

table 4.4 which in turn is based on a combination of the forecast demand by customer segment. The customer segments have been matched to likely house types which in turn gives a total number of installations and duration. The number of installations is then used to calculate the number of surveys.

The demand forecasts above are based on the following:

- Customer segment willingness to retrofit hypothesis
- Demand estimate by customer segment
- Matching of house type to occupant customer segment

It is clear that a key success factor in retrofit is generating demand. Concern about cost and disruption are major factors to be considered when customers are considering retrofit. The first step in attracting potential customers is providing information and awareness of retrofit and the benefits in terms of reduced energy use and carbon emissions. The volumes of demand and customer segments where demand will come from must be treated with some caution. The overall demand numbers are estimates based on achieving sufficient scale to have the capability to retrofit the majority of the UK's housing stock by 2020 and the segments and house types are products of the Experian customer data and the national housing databases used in work packages 1 and 2.

4.3 Supply Chain Design Summary

Key Messages

- Keep the supply chain simple to keep costs down and minimise waste in all its forms
- Focus on the most likely customers to take up retrofit
- Build capability and keep control of quality

5 The Survey Process

In previous reports a value proposition was proposed for the survey element of the retrofit of 4 hours on site work.> We build on the previous proposal of a 2 stage survey designed to manage disruption and minimise the commercial impact together with applying lean process design to reduce the projected time to survey, maximise quality and minimise risk

5.1 Survey Design

In the previous report a two stage survey process was recommended. The first stage survey preceded by a questionnaire, phone interview or internet based tool, would gather enough data to be able to present to the householder a recommendation about the most appropriate interventions to reduce energy consumption for their house type and lifestyle. We estimate this would typically take less than four hours falling in line with the maximum time identified by research with focus groups.

The second stage survey would then take place following an initial commercial proposal and an acceptance by the customer to proceed is established. The 2nd survey would gather all the technical detail required to make and install the proposed intervention in line with the appropriate, guidelines, warranties and legislation. The previous report identified that in order to technically survey a house for all possible interventions and using current industry methods 24.5 man hours would be needed. It is clear that neither a 24 hr. survey split across a number of days nor by a team of up to 4 people for a full day is acceptable in terms of cost or customer engagement and that a reduction in time is required. A traditional improvement approach would potentially only yield up to a 20% reduction therefore a *right to left* approach is required if we are to reach the desired cost and time objective of under 4 hours.

In this report we focus on the following areas;

- *Right to left* process creation for survey 2.
- Labour, competency and tools to carry out a survey.
- Ability to survey for basic and advanced packages with options for added value items.
- Where the survey fits with the engagement process.
- How the survey links with the installation process.

5.2 Survey Workshop Process.

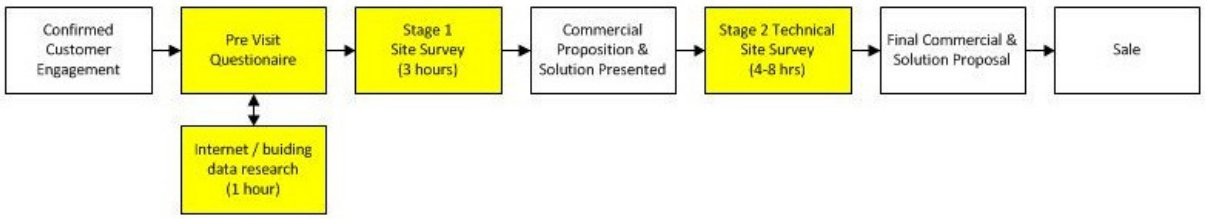
In order to undertake an effective technical survey within an acceptable duration and disruption to the customer a totally new approach was required. Working from *right to left* we performed an on-site analysis of the installation methods for each intervention type. We captured the required standard data for all house types together with possible bespoke requirements that are only applicable to certain house types or features (eg Conservatory, bay window). Standard requirements where possible have been broken down to relevant factors (eg per elevation or room) along with items that appear in the enhanced package (as per WP3.4B Report) to enable a more accurate time per house to be calculated. Detailed timings by intervention can be seen in Appendix 2 Survey Timeline.

Whilst conducting the site based analysis we also captured the required competency and tools needed to survey and estimate risk for each intervention. A summary of the competencies and tools required for the stage 2 survey can be seen in Appendix 3 Survey Rate, Technical Competency and Tool Requirements.

The stage 2 competency requirements can all be found in the profile of the Team Leader of the poly-competent installation team. Furthermore capacity of 1 day per week is available for the Team Leader to carry out stage 2 surveys as identified elsewhere in this report. "Section 6 – Installation."

In contrast the stage 1 survey is more suited to a customer centric consultative approach with excellent knowledge of the effect of the

interventions separately and as a whole package. The diagram below illustrates how the survey process fits into the broader approach to client engagement.



- Engagement steps related to survey in yellow.
- White steps related to sales and integration needs further consideration.
- Stage 2 technical survey time on site and therefore customer impact could be reduced using 2nd person as a lower competency assistant for basic tasks.

- **Figure 3: Customer Sales Process**

Using labour cost for the Team Leader and stage 1 surveyor as detailed in Appendix 3 (Survey Rate, Technical Competency and Tool Requirements), of £30 and £50 per hour respectively, the cost of survey has been added to the table below to provide an overall summary of time and cost per house type for the survey process.

The Bullet points below refer to Table 5.1 which follows

- Stage 1 survey cost standard maximum 4 hour visit irrespective of house type and size allowing for quality customer interaction.
- Stage 1 survey cost includes £20 fuel allowance at £0.45 per mile assuming an average 40 round trip.
- House types listed in line with the Single Dwelling Implementation plan.
- Basic and Enhanced solution matched to the house types identified in the Single Dwelling Implementation plan, Retro Fix and Retro Plus.
- EWI listed as standard or bespoke. Bespoke elements would consist of porch, conservatory or bay windows.
- Not covered in detail:

- MVHR - (suggest separate survey process for houses where this is deemed as an effective solution).Unlikely to be effective until near Passivhaus standards of sealing are achieved.
- Heat pump –As there are limited numbers of heat pumps installed domestically in the UK and those installed struggle to meet the design efficiency we have not considered these in detail at this stage of survey. (suggest separate survey process for houses where this is deemed as an effective solution)

	19th Century Detached	19th C Mid-Terrace	19th Century Conversion	1930's Semi-detached	1950's Semi-detached	1970's Detached	1970's Low-rise Flat	1990's Detached
EWI Standard	X	1:34	1:34	2:10	2:10	2:21	2:10	X
Bespoke	X	2:09	2:09	2:50	2:45	2:56	2:45	X
IWI	3:31	1:04	1:04	X	X	X	X	X
Heating								
Retrofix	1:20	1:20	1:20	1:20	1:20	1:20	1:20	X
Retroplus	1:40	1:40	1:40	1:40	1:40	1:40	1:40	X
Flue Only	0:20	0:20	0:20	0:20	0:20	0:20	0:20	X
Doors & Windows								
Retrofix	0:10	0:07	0:04	0:08	0:08	0:08	0:06	0:10
Retroplus	1:50	1:20	0:45	1:30	1:30	1:30	1:05	1:50
Loft	0:10	0:10	0:10	0:10	0:10	0:10	X	X
Floors	1:00	0:30	0:30	0:30	X	X	X	X
Total Retrofix	**7:01**	**4:45**	**4:42**	**4:18**	**3:48**	**3:59**	**3:36**	**0:10**
Total Retroplus	**8:01**	**6:53**	**7:18**	**6:18**	**6:13**	**6:19**	**5:30**	**1:50**
Stage 2 Cost								
Retrofix	**£350**	**£250**	**£250**	**£250**	**£200**	**£200**	**£200**	**£50**
Retroplus	**£400**	**£350**	**£400**	**£350**	**£350**	**£350**	**£300**	**£100**
Stage 1 Cost	**£140**	**£140**	**£140**	**£140**	**£140**	**£140**	**£140**	**£140**

Table 5.1

The above table demonstrates a variable survey time and cost between house type and level of intervention (Retrofix or Retroplus). A number of potential options have been considered to try and recover the cost of the survey process.

1. Installation Company covers the cost of process and recovers only in the event of a successful sale.

2. Customer is asked to pay for a stage two survey in advance and will be refunded as discount or cash back on successful contract agreement.
3. Customer consents to data capture being made available to 3rd parties and Survey Company sells data to cover cost (likely purchasers, retail, finance and data brokers).

A commercial benefit of providing a "health check" survey could be created through an insurance company discount or "HIP Pack" type scheme where data is recorded during the survey results in reduced insurance premiums to the customer. This could be used to recover the cost of the survey.

In addition to the basic and enhanced interventions in this work package we have also evaluated the possibility and impact of surveying the added value items as identified in WP3.4B Report. It is possible to include 9 out of the 15 added value items within the time and cost listed above. The full breakdown can be seen in Appendix 4 Survey Process for Added Value Items.

5.3 Survey Conclusions

The key messages:

1. The survey process requires two distinct stages. One to establish a solution and sales proposition to the client, and a second to confirm the solution viability and capture details for product manufacture / order.
2. The stage one survey can be conducted within a total of 4 hours through a combination of on and off site research, client questionnaire and interview. The surveyor needs to be capable of conducting an energy assessment, possess a basic understanding of construction and building defects knowledge and be confident to engage in sales and marketing with the client. This person would be salaried at £35,000 PA and therefore create a survey cost of £140 per property.
3. The stage two survey can be conducted in a maximum of 8 man hours dependant on house type and intervention solution. The surveyor will need to possess a significant range of technical capabilities, product knowledge and an understanding of the likely legal constraints whole

house retrofit may incur. The surveyor could also be the Team Leader of the installation team which will de-risk the installation process and facilitate cost certainty. This person would be salaried at £51,000 and therefore create a survey cost of between £50 - £400 dependant on property and solution type. To reduce the stage 2 survey to the target 4 hours, assistance may be required from the stage 1 surveyor or an additional install team member (should there be space in the installation schedule) to perform non-technical tasks.

5.4 Next Steps

1. Further application of Lean techniques to reduce survey time and cost by the development of standard workflow processes, which overlap product related tasks.
2. Further develop the integration required between survey and wider customer engagement / sales processes.
3. Development of competency requirements into a training programme for Team leader in conjunction with installation work stream.
4. Develop finance options leading to a successful sale and explore the relationship between survey, installation and customer engagement.
5. Develop hypotheses of the effectiveness on the first stage survey and how to maximise customer engagement and conversion from interest to a sale. This is likely to include exploring the whole engagement process from awareness, provision of and access to relevant information in conjunction with work package 5.

6 The Implementation Process

This section is an analysis of the current and potential future costs of the Implementation of whole house retrofit, we have attempted to identify where the total costs consumers pay for services are located within manufacture, distribution and installation.

To achieve this we have studied the delivery of whole house retrofit measures using a Poly Competent and undertaken a detailed analysis of the programmes of work needed for each house type; together with the likely costs involved in setting up and running the team as a business. The findings are presented here together with an estimate of the overhead costs that are likely for the proposed delivery organisation. Material costs presented here include distribution, stock holding, last mile transport etc. together with a summary of where we consider costs may be reduced and how.

6.1 Summary of retrofit programmes by house type

Customer segmentation work has defined that the market for retrofit works will be confined to early adopters who represent between 15-30% of UK households, as initial take up is unknown we have designed our approach around a delivery concept that is based on a small self-contained dedicated team of people, as opposed to the multi trade approach currently utilised, we believe this will allow the work force to grow organically to meet demand. Previous work demonstrated that all works, associated with Retrofix, could be delivered within the desired time frame utilising a dedicated work force with a peak manpower requirement of no greater than 4 operatives.

	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

Table 6.1: Programme time and Manpower for retrofix measure installation

6.2 Poly-competence Requirement

The large corporate delivery approach to delivery of multiple measures in the refurbishment market, which has been used in the delivery of the decent homes programme, relied on using operatives with an individual competency set; our model will require multi competent operatives who will be split into three categories, each with the following competency:

Table 6.2: Competency Summary

Low Competency	• General Labouring • Installing Insulation board • Installing Loft Insulation
Medium Competency	• Plastering • Rendering • Carpentry • Decoration • Tiling • Basic Plumbing • Basic Electrics • Basic roofing • Scaffolding/Access
High Competency	• Electrics to Part P • Gas Safe Engineer

In order to understand the competency requirement of the team we have undertaken further analysis of the work-study programmes to understand what the competency requirement of the dedicated team would be.

We have recorded the competencies required for the retrofit basic package to all house types based on occupied and vacant scenarios; these can be found in Appendix 5. The modelling demonstrates that in the worst case scenario, pre 1919 detached property there is never more than a requirement for 25% of the time to be fulfilled by an operative with High competency, and in this case the majority of the requirement being fulfilled by Mid competency operatives

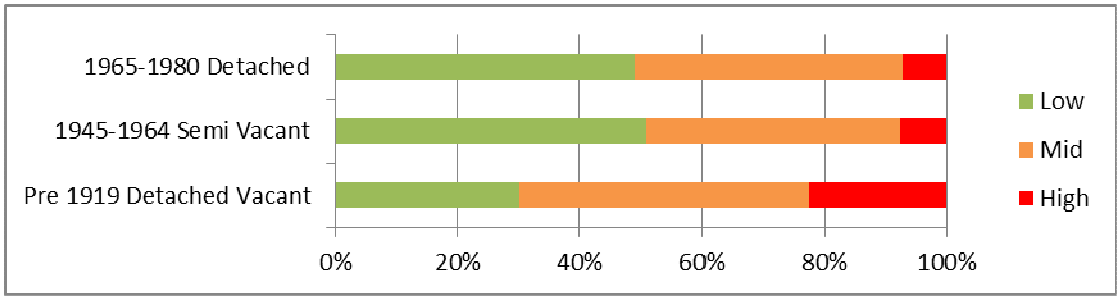


Table 6.3: Competence Requirements by House Type

This suggests that a team comprising of four operatives with the following competencies would have the ability to deliver all required measures across all house types:

Team member 1

Table 6.4: Lowest Skill Team Member

To fulfil the programme requirements we would expect the operative to have the following competencies:

Working safely and efficiently in the Refurbishment industry

- Conforming to General Health, Safety and Welfare in the Workplace
- Moving, Handling and Storing Resources in the Workplace
- Erecting and dismantling simple access equipment
- Painting a timber window frame
- Applying emulsion to wall by roller
- Painting doors and frames
- Applying oil based paint to walls by roller
- Removal and refitting a water-filled radiator
- Repairing a patch in a plastered wall
- fixing floor tiles and skirting tiles
- Connecting plastic fittings to a utility sink
- Connecting plastic fittings to a cold water cistern and central heating header tank
- Cutting, bending and threading conduit
- Cutting and bending trunking
- Applying, producing and installing insulation.
- Applying Insulation and Finishes to Cylindrical and Flat Surfaces
- Install cavity wall insulation.
- Install draught-proofing to opening
- Install loft installation

These competencies could be attained via current City & Guilds courses and we would anticipate knowledge up to level 1 Accreditation

	To fulfil the programme requirements we would expect the operative to have the following additional competencies: • Erecting and dismantling access equipment, handling and moving resources • Fixing skirting to a timber background • Fixing floor joists and laying flooring • Rust removal and priming metal • Transferring levels in plumbing • Working with non-manipulative compression fittings • Copper pipe bending and jointing • Working with steel pipework and fittings • Installing a 1-way lighting circuit • Scrim and skim finish with plaster. • Applying a plain rendering and finish with a wood float • Fixing bell cast bead and applying scratch coats to wall areas • Applying pebbledash finish to prepared wall. • Installing Glaze Tiling • Installing Kitchen Units These competencies could be attained via current City & Guilds courses and we would anticipate knowledge up to level 2 Accreditation

Table 6.5: Mid-Skill Team Member

Team member 3	
	To fulfil the programme requirements we would expect the operative to have the following additional competencies: • Working at height • Harness training • Asbestos awareness • Abrasive wheels training • Emergency First Aid at Work These competencies could be attained via current City & Guilds courses and we would anticipate knowledge up to level 3 Accreditation

Table 6.6: Skilled Team Member

Team member 4	
	To fulfil the programme requirements we would expect the operative to have the following additional competencies: • Understand how to organise resource • Estimating resources • Resolving basic construction problems • Waste and Waste Management in Construction • Understand and apply domestic central heating system installation, commissioning, service and maintenance techniques • Understand and carry out electrical work on domestic plumbing and heating systems and components • Understand and apply domestic sanitation system installation, commissioning, service and maintenance techniques • Service and maintain domestic oil firing pressure jet appliances • Service and maintain domestic solid mineral fuel burning appliances • Install, test and commission domestic biomass fuel burning appliances • Install, commission and handover 'active' solar thermal hot water systems • Install, commission and handover heat pumps' non-refrigerant circuits • Know the requirements to install, commission and handover rainwater harvesting and grey water reuse systems • Understand and carry out electrical work on domestic plumbing and heating systems and components • Understand core gas safety principles for natural gas within domestic building services engineering. • Understanding of the Building regulations for electrical installations in dwellings. • Surveying for energy efficiency measures • how to commission heating and hot water systems and handover to the customer. These competencies could be attained via current City & Guilds courses and we would anticipate knowledge up to level 3 Diploma Accreditation

Table 6.7: Team Leader

6.3 Quality control and quality of installation

Consistency of installation quality is vital if the take up of retrofit is to be successful, this is also important for the long term performance of installed measures. We propose that installation teams are responsible for the installed quality and cosmetic appearance of installed measures. the high level organisation in our ideal supply chain design will be responsible for the specification and qualification of solutions together with the development of installation methods and robust standard work. This is underpinned by competence based training, qualifications, and accreditation.

6.4 Other efficiency measures

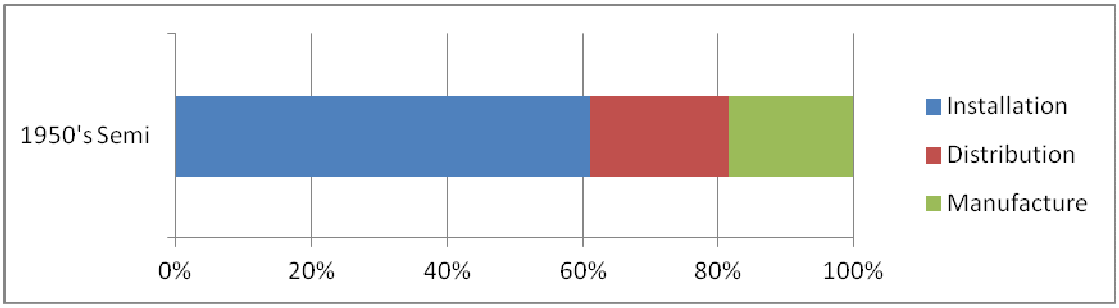
The retrofit market is currently constrained by the lack of consumer demand for installing energy efficiency measures; we believe that a contributing factor in this is the current costs charged to building owners for many of the measures required to improve energy efficiency, our research has demonstrated that this is due to a number of factors:

- Immature market (particularly for solid wall insulation and certainly for "whole house retrofit"
- Process Waste
- Inefficient delivery
- Lack of innovation in product
- Lack of standard methods and standard work for installation of measures

Our proposal is that by utilising a polycompetent team, redesigning the material supply chain to remove waste from the process, and introducing process efficiency to eliminate on site waste we can reduce the cost to within an affordable threshold to allow market growth. The next stage of cost reduction will need to come from product innovation and development of standard methods and supporting robust standard work

We have modelled the costs of applying a retro fix package to a 1950's semi-detached property, the full detail of this can be found in Appendix 6.

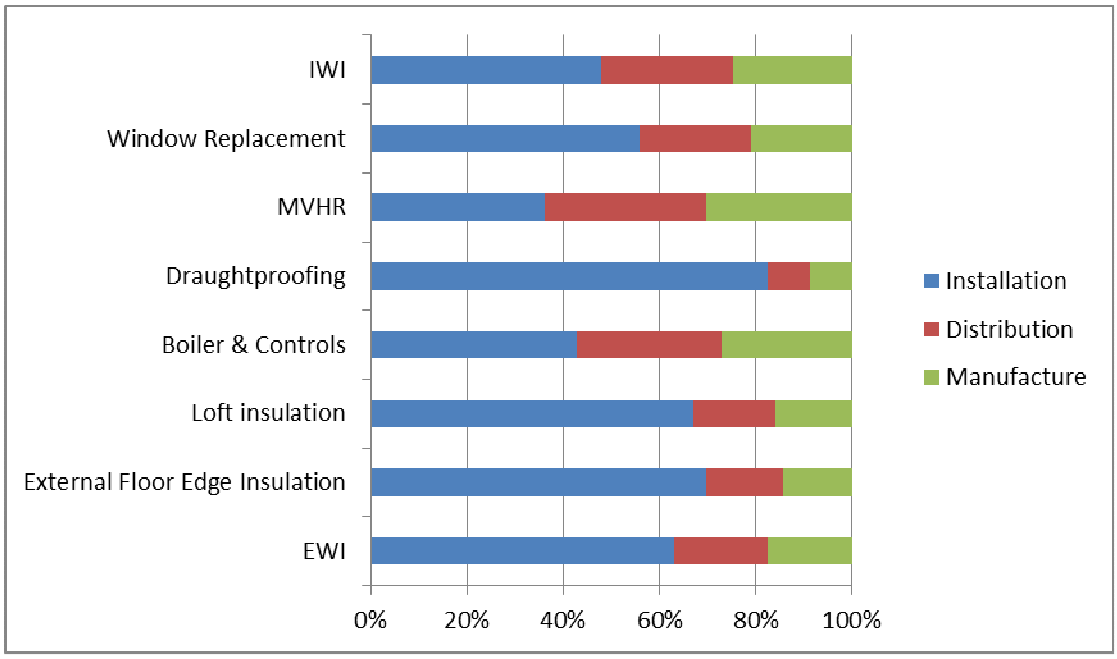
Table 6.8: Distribution of costs for the Retrofix to a 1945-1964 Semi



6.5 Labour intensity by measure

We have undertaken further analysis (appendices 11 and 12) to understand if the cost split is dependent upon measure and how this is distributed amongst labour, materials and distribution;, the chart below demonstrates that some measures are more labour intensive than others

Table 6.9: Distribution of costs at today's rates, using the poly competent team, by measure



This suggests that innovation around process and material that reduce labour time should be focussed on the following areas:

- Internal Wall Insulation
- External Wall Insulation
- External Floor edge Insulation
- Draught proofing
- Window Replacement

With the following measures efforts should focus on reducing manufacturing cost:

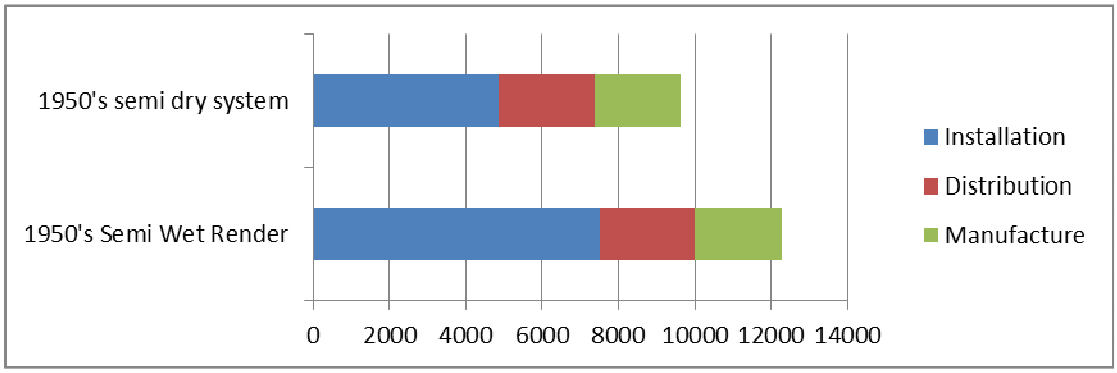
- MVHR
- Boiler & Controls

Current methodology for EWI products is labour intensive with a multi stage manual operation. Innovation could lead to a rendering solution that involved a dry fit, dry finish system reducing the amount of manual labour required. Within our hourly programmes more than 50% of the labour time involved in the installation of External Wall insulation is taken up by the application of the two coat wet render finish. It is possible that the insulation board could be supplied

with the finish coat bonded to the outside, similar to a Structurally Insulated Panel or SIP system used in new build, these rigid pre finished panels could be applied to the outside of the building with no need for the application of a wet render finish, this innovation alone would deliver a 22% reduction in costs, providing there was no increase in material cost.

We are in discussion with a number of developers of these products which are currently in the development stages and are likely to be highly practical solutions reducing labour time and skill in application.

Table 6.10:External Wall Insulation - Cost reduction on 1945-1964 Semi if install time reduced by 50%



AN objection to External wall insulation is the physical appearance, there are currently a number of solutions available providing special finishes such as a brick façade, these are however expensive and time consuming to apply. The solution preferred by planners is to internally insulate the front of a property and externally insulate the rear. We would suggest that a solution could be to develop off site manufactured solutions similar to a SIP panel whereby the existing building appearance could be replicated onto the new façade, buildings would be laser scanned prior to commencement and insulated panels manufactured off site.

6.6 Cost of the Installation Team

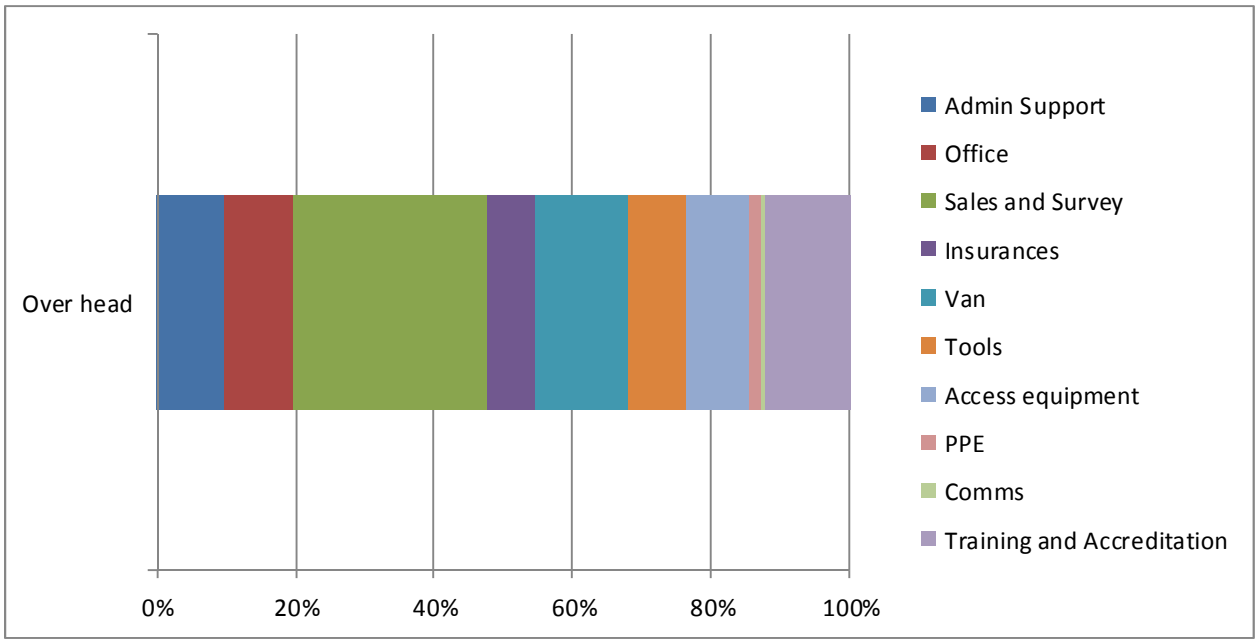
In order to understand where the split of cost lies we have modelled installation using our poly-competent delivery model and have engaged with the supply

chain to establish employment costs for the operatives required within the team as follows:

Table 6.11: Team Skills / Cost Matrix

Competence	Annual	Month	Employer Cost	Efficiency	/hr.	Current Contrast
 Low Competency	£18,000	£1,450	£19,450	76.92%	£9.97	Labourer £8.72
 Medium Competency	£21,000	£2,100	£23,100	76.92%	£11.85	Carpenter £11.31 Plasterer £12.17
 High Competency	£51,000	£7,004	£58,004	76.92%	£29.75	Multi Trade £15.49 Site Manager £30.34

Table 6.12 Breakdown of overhead for Poly-competent team

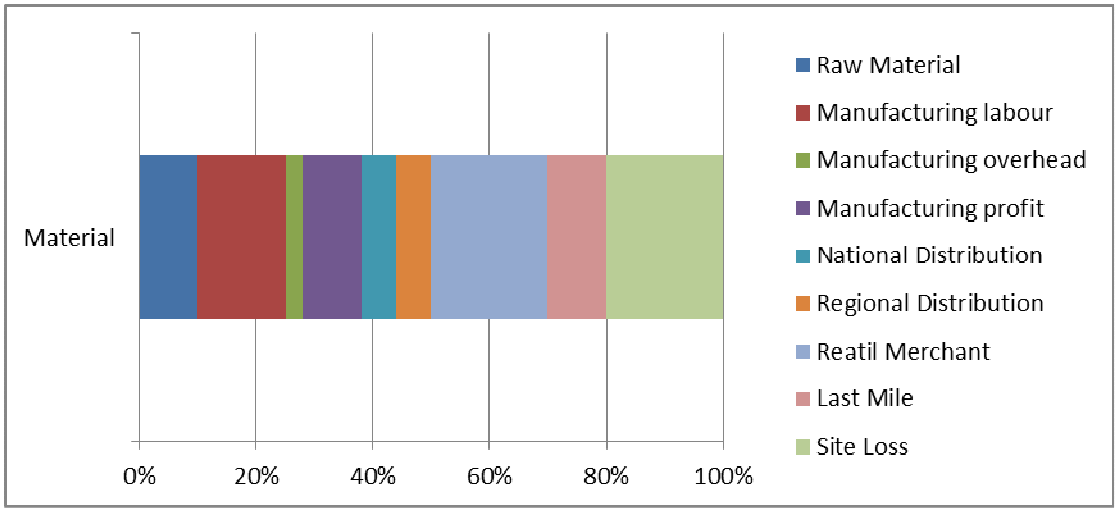


We have included a full breakdown of how this cost is assembled in Appendix 7.

6.7 Cost of the Material

We have made attempts to understand the breakdown of costs within material, and have received resistance from the material supply chain to provide information. From unattributable discussions and experience of team members we have been able to estimate the split to be as follows:

Table 6.13: Breakdown of material supply costs



From experience with similar supply chain works we believe that the following reductions could be made:

National Distribution	100%
Regional Distribution	40%
Retail Merchant	20%
Last Mile	50%
Site Loss Damage	50%

From the table above.

- 100% reduction of national distribution achieved through removing the need for a national distribution centre for retrofit products. Manufacture in

the UK and shipping direct to consolidation / distribution centres would accomplish this

- Regional distribution 40% reduction achieved through variety reduction, pull systems for stock control, increased volume.
- Retail Merchant 20% reduction achieved through reduced sales overhead through on line ordering and simple consolidation.
- Last Mile 50% reduction through single delivery using a purpose built consolidation container
- Site damage / loss 50% reduction through purpose built container and effective methods / standard work

Table 6.14: Potential Distribution & Logistics savings vs. current cost.

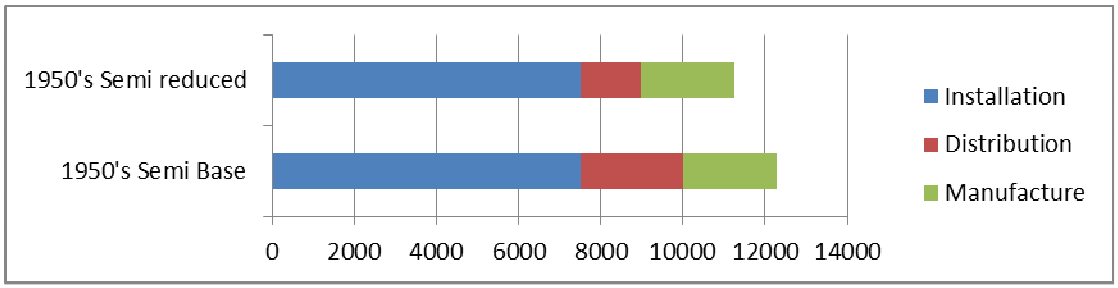


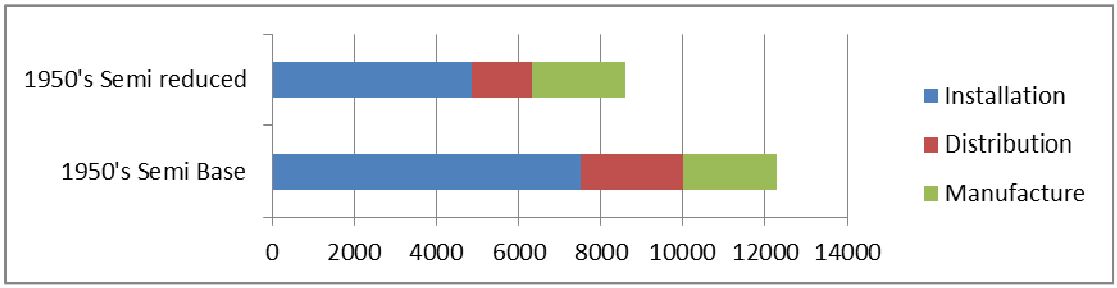
Table 6.15 Cost reduction on 1945-1964 Semi with assumed material supply reductions

Costs of installation for 1950's semi detached house using current methods and realising material distribution savings as explained above.

This would result in a reduction of 9%. We believe that the possible reduction is much bigger than this, in the region of 40/50%, this will be explored in detail in the following work package WP4.5

If we are to take this assumption and model it with the reduction in the installation process previously discussed this generates a 30% reduction in install costs

Table 6.16: Cost reductions on 1945-1964 Semi with assumed material supply reductions & EWI install time reduced by 50%



1945-1964 semi detached house showing costs to install external wall insulation with distribution costs savings (described above) and labour time reduced by 50% through product innovation

6.8 Poly-competent Installation Summary

The research undertaken on the Poly competent team approach suggests that there are significant time savings to be gained versus the traditional approach; this is due to:

- sequencing of works to avoid loss of production from over laps in trade.
- Lower overhead for a small self directed team

The advantages of the new delivery process will be in its ability to scale organically to meet market demand and offer progression for the workforce through a sustainable employment model this should relate to a lower overhead as it is less linked to specific trades work than the traditional model, having a workforce that can apply itself to a number of measures should also equate greater productivity

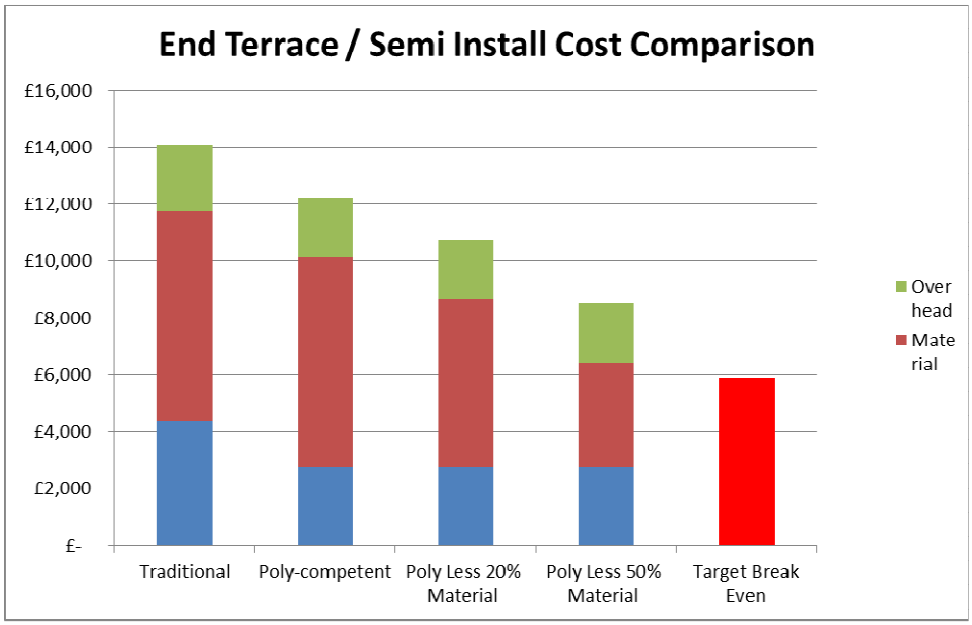
The current material market is designed to meet a different need than retrofit, and as the whole house retrofit market is currently immature there is little in the way of specific products, a number of products currently used are those designed for the new build market, where there are different performance criteria. There is considerable scope to reduce labour time through materials that minimise on site activity, with the example of EWI which is currently a three stage process of

applying insulation, base coat and then top render coat. If this could be reduced to a single dry fix operation labour time could be reduced by more than 50%. In addition current costs for EWI are tied up in the purchase of systems which have expensive warranty arrangements attached, if there is no longer a client requirement for a warranty backed system cost could be reduced by procuring components separately.

The potential benefits of poly-competent installation and further material savings can be seen in the following example for a semi-detached house. The Target breakeven cost is taken from the WP4.3 where an 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

Table 6.17 End Terrace / Semi Detached Install Cost Comparison.



There is further cost reduction in standardisation of material supply, the industry currently calls for multi thickness of insulation products and multi output boilers if these could be reduced there is further scope for cost reduction.

As part of our research we have been able to identify archetype solutions, in order to prove the costs savings we are proposing the assembly of a sample project at a scale within a specific geographic region. Using this sample project we intend to apply the various delivery scenarios benchmarked against the traditional approach, we believe this approach will provide the evidence base to prove the 50% cost reduction we believe is deliverable from the elemental approach we have currently undertaken.

The key to a lower cost delivery model will be a long term market delivering at scale, with a delivery vehicle that is not tied to a particular technical solution but one that is poly-competent to meet varying demand for a range of solutions.

By reducing loss of productivity through better sequencing, certainty of works and process efficiency we can significantly reduce costs throughout the supply chain.

The conclusion is we have evidence that is demonstrating there are cost savings to be provided through the new delivery vehicle, and in order to realise the full potential we need to achieve collaboration from project partners and the wider supply chain.

6.9 THE KEY MESSAGES:

1. Greater transparency of the distribution of cost within the existing supply chain will allow for incremental cost reductions to be achieved, quick wins should be achievable through optimisation of existing process.
2. Large reduction in cost (Circa 30 to50% is considered to be achievable) will require new process and new material innovations and reconfiguration of the supply chain
3. The quality of measures is vital to long term performance and to the reputation and hence mass take up of retrofit. Standard methods and robust standard work and continual refinement will be needed to deliver this

4. There is substantial investment in the establishment of a new delivery vehicle this will need to be supported by the long term visibility of a retrofit market, as the market grows there is likely to be a number of viable delivery options, however a vehicle which is able to "flex" to suit demand will be required at the outset.
5. Increasing capability of delivery teams is vital to deliver great customer experiences and fuel demand for retrofit

6.10 Next Steps

1. Further work is needed to identify existing training courses and their applicability to fulfil the competency requirement is needed.
2. Further in depth interrogation of the supply chain for materials is required to understand the material distribution value stream and identify opportunities to reduce cost through reductions in material movements, stock holding and other processing (Circa 30 to 50% is considered achievable)
3. Further analysis on the required innovations in onsite process by measure is required.
4. Take up of measures will be driven by the associated energy saving of a particular product. Detailed cost benefit analysis for each intervention will be required; including areas where innovation is needed.

7 Through Life Support.

Through life support of whole house retrofit measures is likely to be more affordable than when installed individually and offers customer peace of mind and hassle free maintenance with minimal disruption. It is proposed that the installation company takes responsibility for support giving ownership and

providing a long term relationship with the client. Research work carried out for Work Package 5 suggests that it is unlikely that there will be much take-up of this service

7.1 Support and upgrade Service

An assessment was carried out on the likely maintenance and upgrade activities that are needed in support of whole house retrofit. This assessment is included in full as Appendix 10. Work carried out as part of work package 5 has however concluded that customers are unlikely to want maintenance support packages as part of the retrofit, but prefer to have comprehensive and dependable long term warranties covering all retrofit work carried out. It is unlikely that solutions embodied will be free of all maintenance and periodic inspection, for example heating and ventilation devices will most likely require an annual service / safety check throughout their useful life. It could however be beneficial to carry out minor visual checks to the property and advise the customer on repair / remedial work that becomes necessary over time. It would be advantageous to the retrofitter to maintain an on-going relationship with the customer and it is suggested that the annual gas service is used as the basis for a more comprehensive dialogue with the client to include:

- Review of energy use
- Inspection of potential problem areas, damp, mould, render cracking etc. This will include dealing with any warranty claims on behalf of the customer.
- Lifestyle changes, ie. Children leaving home and re-tuning heating systems for best economy.
- Provision of other measures, Solar PV / hot water, water saving devices etc.

The through life programme will need to be linked in with the sales process to provide a transparent strategy to the customer and avoid the perception of being "upsold" The benefit of a whole house maintenance / support plan is likely to be less intrusion for the homeowner and more affordable if the poly competent approach is taken to support as well as installation.

7.2 Different Support Packages For Different Tenures

There is likely to be a different need for through life support for retrofit measures for different tenures. For example in the social and private rental sector there is the requirement for annual gas and electrical safety testing, it is likely this will be delivered with a maintenance contract than in the owner occupier sector. Other forms of obligation could arise if new financing packages emerge for retrofit measures such as leasing of boilers as a way to reduce the up-front cost of retrofit. These options will be explored in later reports.

8 Retrofit Demand

Since there is no established retrofit market in the UK, we have established a hypothesis based on who is most likely to take up retrofit, which house types they live in and where they are located. This has helped us build a model for demand from now until 2020 based on achieving an installation rate of 400,000 houses by this time

8.1 Background

Organisations, delivery teams, materials and technical solutions, affordability and disruption for the homeowner all need to be improved to achieve mass demand. To reduce the cost of retrofit and provide an improved customer experience future delivery capability will need to reflect the Poly Competent retrofit team competency profile and build towards delivering this through the different delivery models developed in earlier reports. To support the improvement of retrofit capability the accreditation system will need to be streamlined and improved, there are only 2 mandatory accreditations covering gas and electrical systems but there are currently many more which are needed to access warranties and insurance. Some of these accreditations are specific to material and systems manufacturers and others link back to the supply chain silo such as doors and windows. To assist the retrofit market a single retrofit accreditation body is

desirable covering all technical interventions and provide access to warranties and insurance, this could be similar to the National Housebuilding Council (NHBC) scheme for new homes.

8.2 Delivery Capacity Required

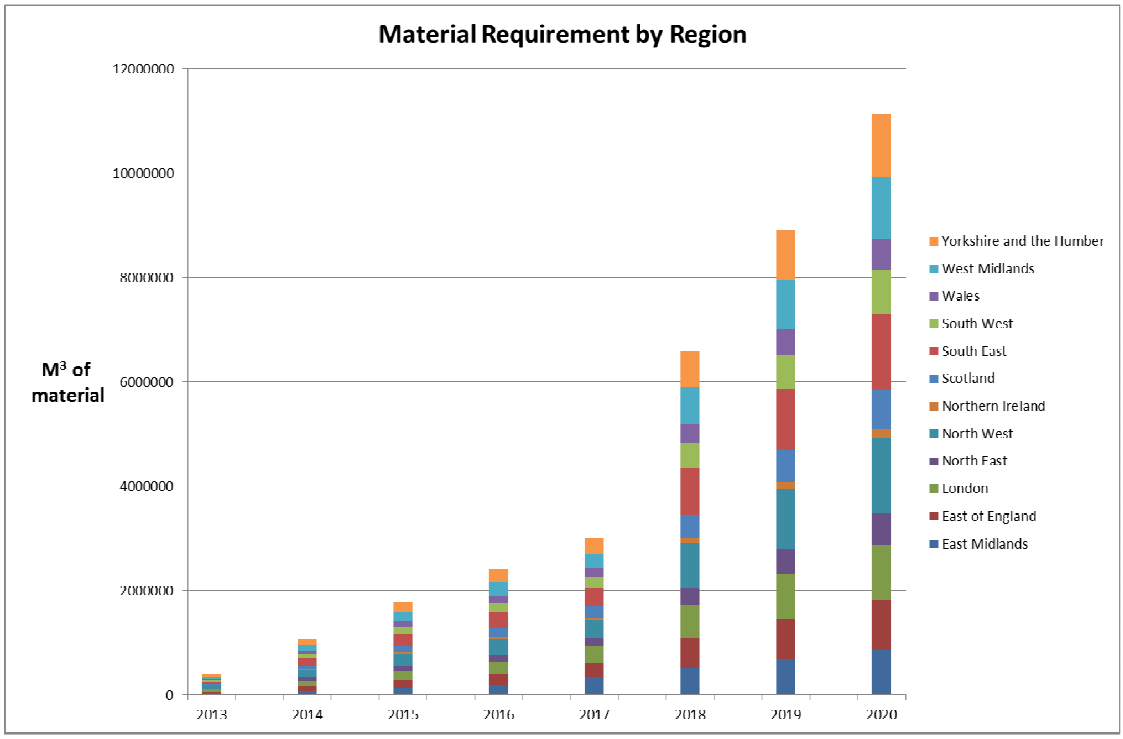
An estimate has been made of how demand could build over time and uses the work on customer attitudes from Work Package 5 to assess the likelihood of different customer segments taking up retrofit. The most open customer segments are shown to generate demand first with other segments following on over time as demand builds, the assessment criteria for customer segment likelihood to retrofit is attached as appendix 9 The trajectory results in an overall UK capacity for retrofit of 400,000 houses per annum by 2020, this is the rate which we believe is necessary to achieve the majority of 26 million UK homes to be retrofitted by 2050. The graph of demand by customer segment is shown in table 4.1 in section 4 of this document.

This then uses information from Work Packages 1, 2 and 5 taking the house type distribution, matching customer segments to house type. An estimate was then made of how demand will build over time and how this will be distributed among customer segments; it is assumed that current retrofit delivery will continue in the social housing sector and remain flat. Anticipated numbers of retrofit teams and surveyors are shown in tables 4.5 and 4.6 in section 4 of this document

8.3 Material capacity required

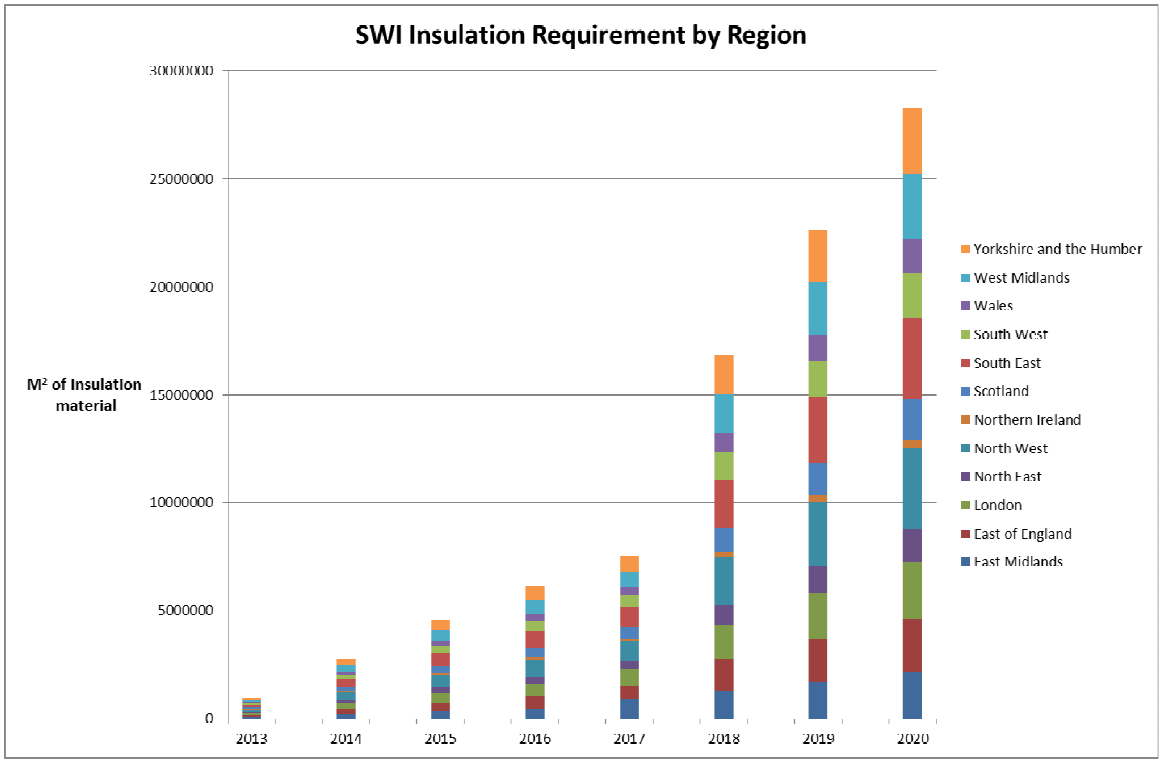
The estimated demand profile by customer segment and house type by region was used to calculate the overall material volume requirements for retrofit over time. The results are shown below.

Table 8.1 Material Capacity by Region



The above table shows regional material requirements over time to deliver the retrofit hypothesis developed here. The amount of material per intervention has been estimated and applied to the demand forecast for that house type. The material estimations per intervention can be found in Appendix 8

Table 8.2: Evolution of Solid Wall Installation Capacity



The chart illustrates a steady growth in requirement for material from 2013 to 2017 with an almost doubling of supply from 2017 to 2018, however the SWI market will be split between EWI and IWI.

Table 8.3 External Wall Insulation Capacity (EWI) Evolution by Region

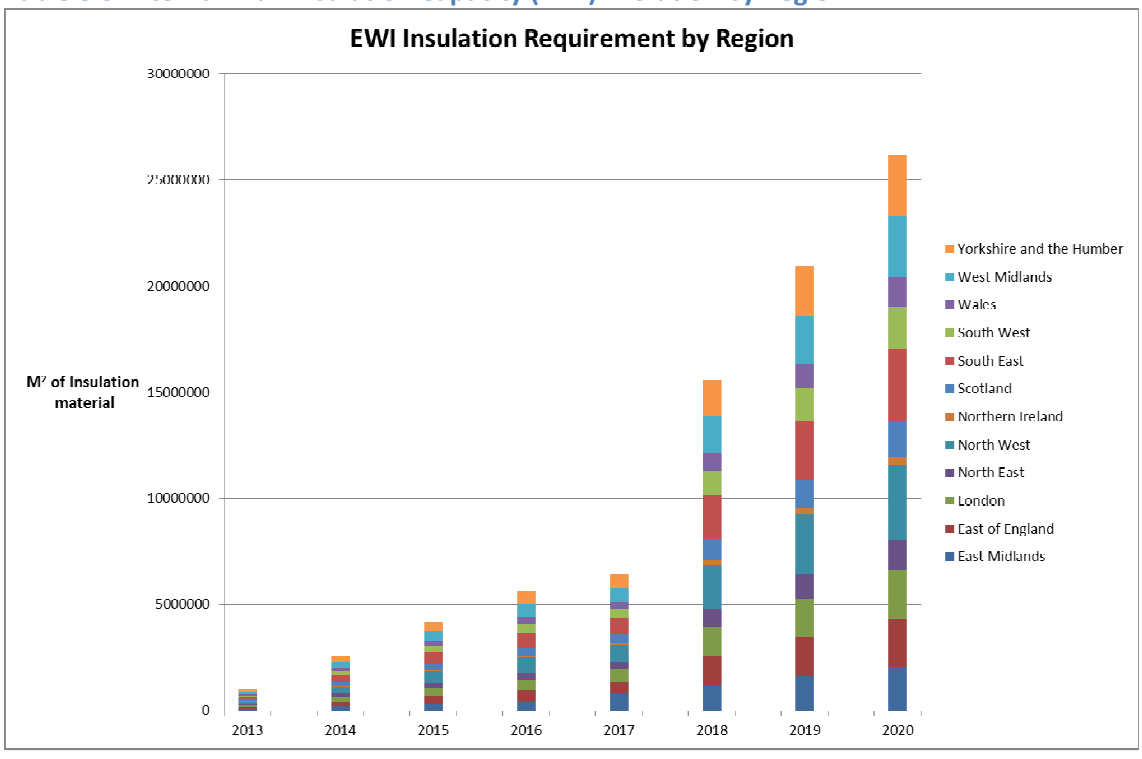
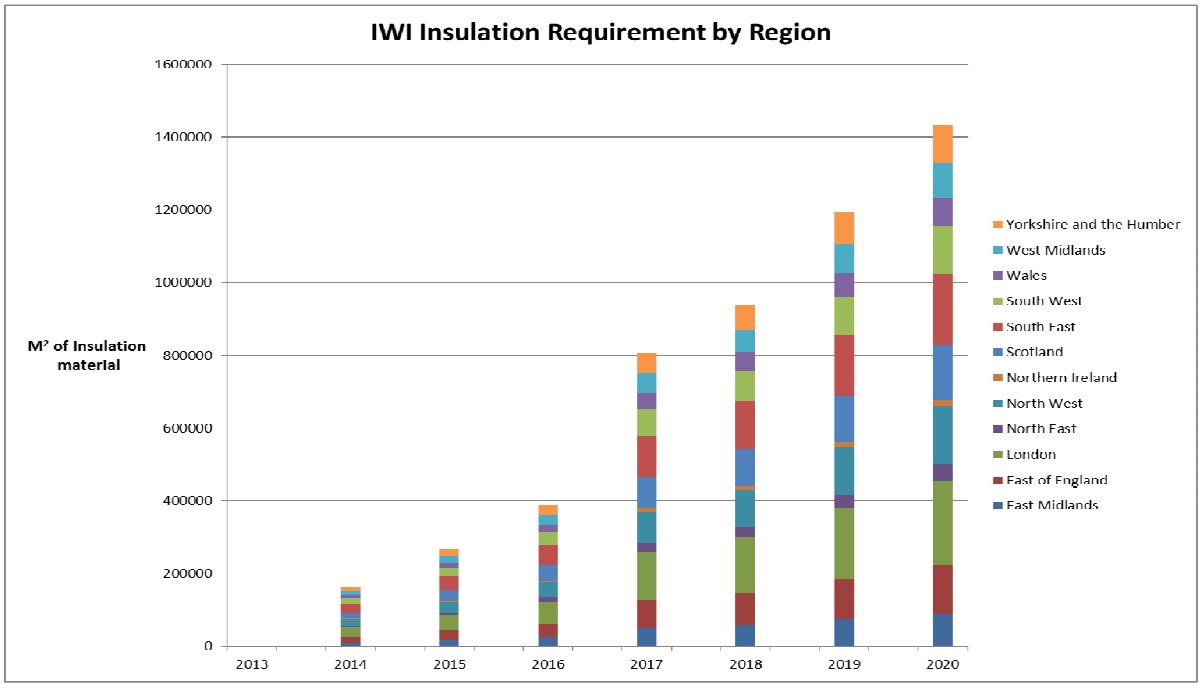
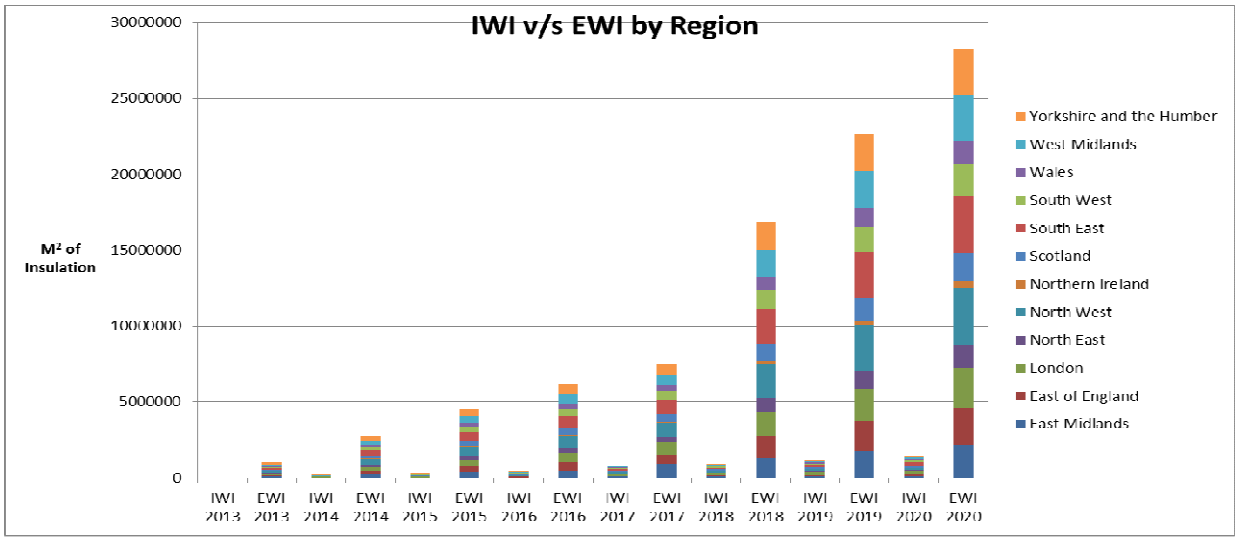


Table 8.4: Internal Wall Insulation (IWI) Capacity Evolution



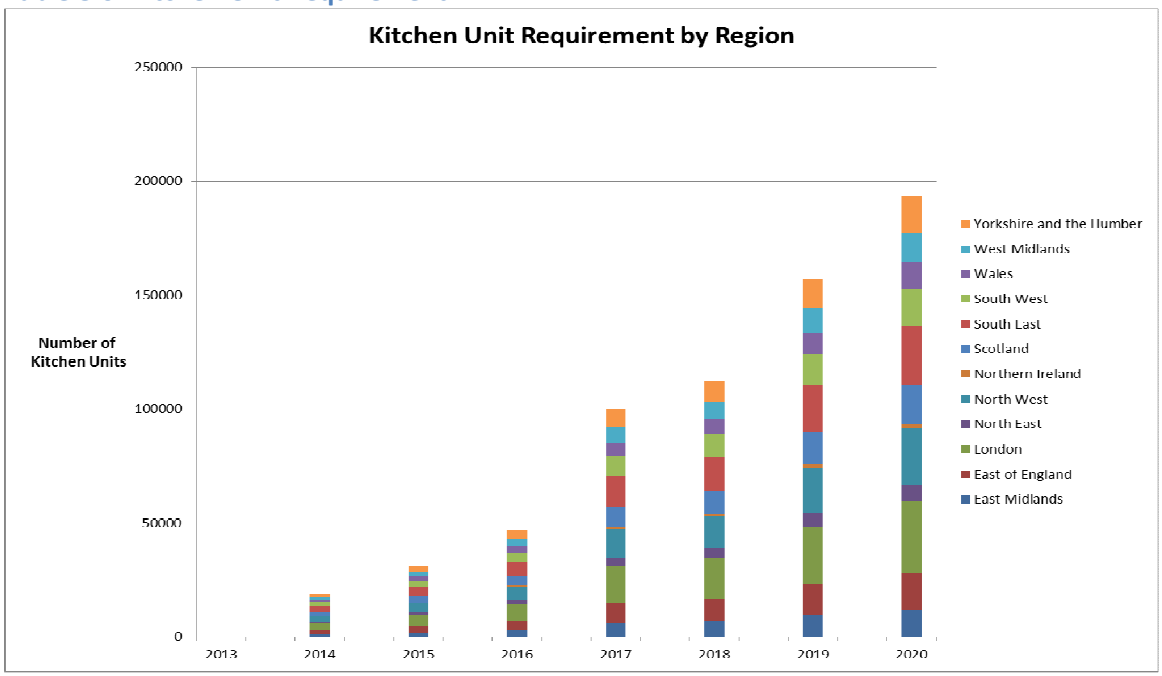
The above charts illustrate that the market for IWI is significantly smaller than that for EWI with the total SWI market in 2020 being 29 million square metres; EWI represents 95% of the total market. We will need to determine if the potential size of the IWI market is enough to facilitate the reduction in cost required for materials such as aerogel. There is also a noticeable difference in regional split of IWI to EWI with London clearly showing an uneven share of IWI to EWI. bacause heritage building requiring internal wall insulation to at least the front elevation.

Table 8.5: EWI vs. IWI Capacity Contrast



Demand for replacement kitchens needs to be considered as this is both a potential trigger point for retrofit and in the case of application of internal wall insulation kitchens must be removed and /or replaced as part of the process.

Table 8.6: Kitchen Unit Requirement.



In the case of boilers and controls / thermostatic radiator valves we consider that replacement will migrate from "fix it when it's broken" to be part of a whole house retrofit. Overall volumes will therefore increase modestly over time.

Table 8.7: Replacement Boiler Volumes

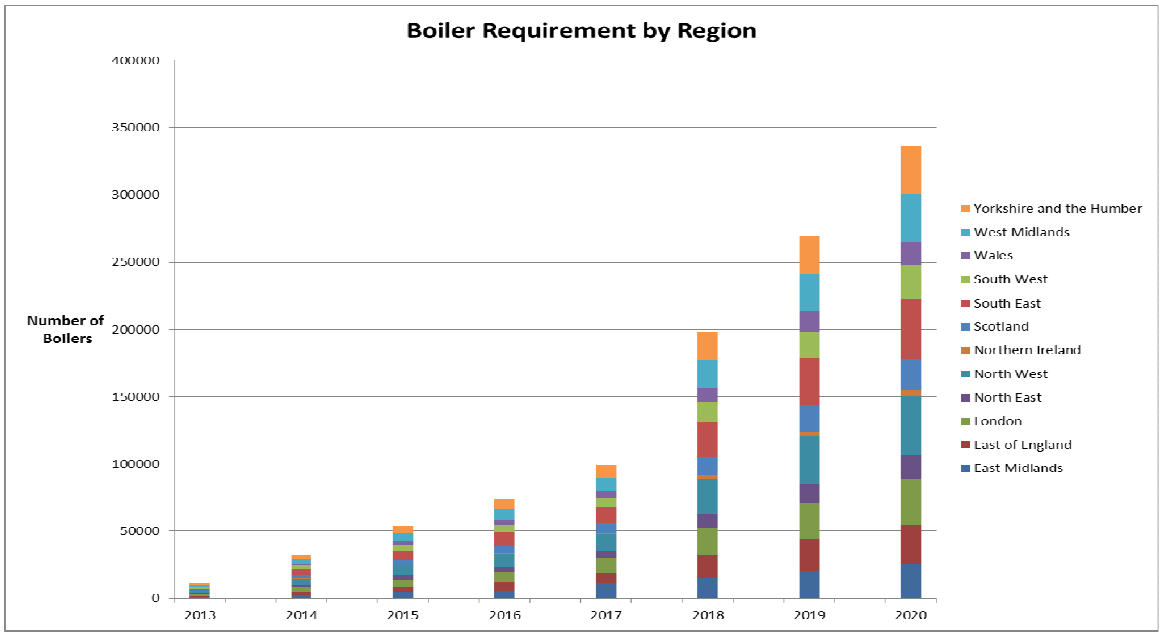
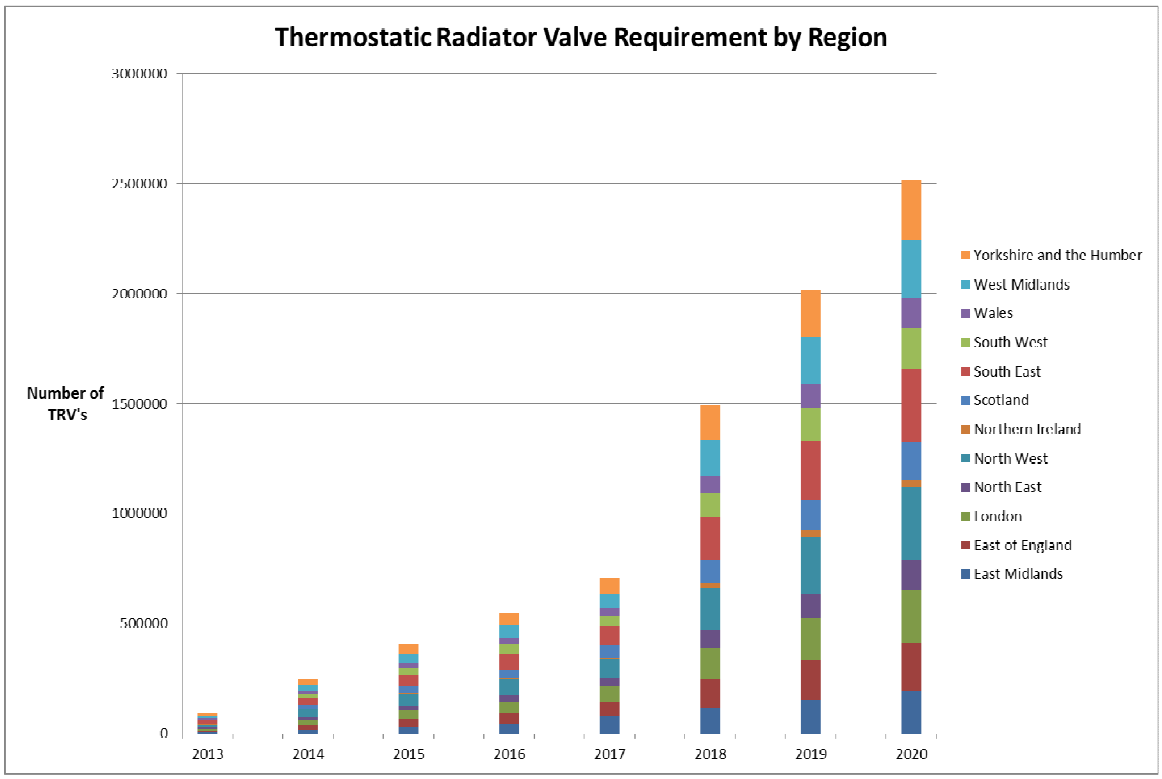


Table 8.8: Thermostatic Radiator Valve Volumes



Material availability to cover the anticipated relatively slow growth envisaged in this report is not considered to be a problem. Manufacturers will respond with greater capacity when the market is proven and investment in additional capacity is seen to be worthwhile.

The main supply route and for products exclusively for whole house retrofit is currently through a network of builders merchants. Examples of the regional distribution outlets are illustrated on the following maps. These show that there is existing national coverage for supply for materials and products for retrofit Travis Perkins and Jewsons have over 1,100 branches across England, Wales, Scotland bt not Northern Ireland where there only appear to be independent merchants. The configuration of the supply chain using the merchant supply model does not conform to the "least wasteful supply chain" described here but this illustrates that merchants could decide to migrate from supplying materials piecemeal to becoming retrofit consolidation centres.

Figure 8.1:
Regional Distribution of Jewson Builders Merchants

Figure 8.2:
Regional Distribution of
Travis Perkins Builders Merchants

9 Conclusions and Next steps

9.1 Conclusions

This report presents further study of what is required to provide the first and second stage survey and installation of the measures identified in Work Package 3.4a to the main property archetypes. We consider the most effective way to build an industry is for delivery to be via small (4 people) highly effective teams and the team leader to be involved in the second stage survey to give ownership of the outcome of retrofit from an early stage.

An assessment has been made of the likely cost of retrofit for the property archetypes considered, and how demand could build over time and where demand is most likely to come from; retrofit costs of under £10,000 for most property types appears to be feasible but further work is needed to understand cost in material distribution. We conclude that demand is likely build slowly and come from the older age groups who have some spare money and want to safeguard themselves from rising fuel process and to keep themselves comfortable into their retirement.

Material availability is unlikely to choke the take up of retrofit and current distribution networks exist to provide sufficient capacity to deliver product throughout the UK. The supply of products such as windows and doors, boilers

and heating controls is likely to form part of a retrofit rather than perhaps be individual purchases as householders adopt a "whole house approach" For products such as solid wall insulation there will need to be a growing capacity to fulfil demand and this is a largely new area for the owner occupier market.

The real challenge is to develop a training and accreditation system that is straightforward and provides different entry points into retrofit and supporting qualifications to allow people from different trades / backgrounds to enter the market quickly while controlling competence and the delivered quality of retrofit measures.

Through discussions with existing players in retrofit it is clear that few people understand the true value in creating a new supply chain for retrofit despite the poor performance and reputation of the current industry. Some within the industry are keen to become beacons of excellence and see a profitable niche in retrofit. Realising the solutions presented in this report will mean confronting and destroying the current industry paradigm and creating new enterprises to deliver whole house retrofit brilliantly.

9.2 Next Steps

This report presents a number of suggestions on the manpower, materials and regional coverage that will be needed to establish a credible industry; this will need to expand at a rate that will deliver the UK's Carbon Reduction Commitment. It is important that the hypotheses developed here are tested and commented upon by industry experts and their comments embodied in our thinking going forward. In addition, further work is needed to engage with key players in the supply of materials and products needed for retrofit to fully understand how cost is built up through the value stream, from raw ingredients to products embodied on site. Representatives of the existing supply chain have

been reluctant to share cost information, details of how products are distributed and how cost is built up as this is seen as highly commercially sensitive.

It is our challenge to build trust with key players and work to understand how a 50% reduction in cost of products delivered to site could be made possible. In addition we need to work with product developers and manufacturers to challenge them to develop products that require less labour on site and are unaffected by prevailing weather conditions. Specifically to move away from wet finishes for solid wall insulation.

The need to develop and understand the competencies required for retrofit and how training could be provided to allow conversion from other trades or new starters to be provided must be explored and the team profiles presented here will be used as a starting point.

The reports that follow will present a commentary on how the supply chain could adapt and reinvent to provide the needs of whole house retrofit and propose a road map with time scales for change. In addition gaps between current and future supply chain needs will be examined for materials, manpower, products and process requirements. This will include an assessment of the competences required at each stage of the supply chain, (materials manufacture, consolidation, fabrication, scheduling, distribution, property surveying, retrofit installation, quality control. And accreditation) and what training is required to support this.

10 Appendices

Appendix 1

Matrix of measure house types

MATRIXOFMEASURE
S.xls

Appendix 2:

Survey Timeline

WP4.4_Appendix 2
Survey timeline.xls

Appendix 3:

Survey rate, technical competence and tooling required

Wp4.4_Appendix 3
Survey rate tech com

Appendix 4:

Survey Process for added value items

Wp4.4_Appendix 4
Survey proess for ad

Appendix 5:

Skills matrix

WP4.4_Appendix 5
Skills Matrix.xls

Appendix 6:

Cost breakdown 1950's semi

WP4.4_Appendix 6
Cost Breakdown- 195

Appendix 7

Overhead calculation for team

WP4.4_Appendix 7
Overhead Calculation

Appendix 8:

Material volumes

WP4.4_Appendix 8
Material Volumes.xls

Appendix 9:

Customer segment targets

Wp4.4_Appendix 9
Customer segment ta

Appendix 10:

Through Life Assessment

Through Life Plan.xls

Appendix 11

WP4.4_Appendix 11
Material Cost EWI.xls

Appendix 12

WP4.4_Appendix 12
Other Material Cost.x

Appendix 13

regional capacity.xls