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International review of domestic retrofit supply chains

Final report

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Contents

Executive summary

Research aims and objectives

BEIS commissioned this research project to bring together the relevant international evidence and create an overview of domestic energy efficiency retrofit supply chain practices in different countries. The aim was to identify the factors leading to a successful retrofit supply chain and examine whether they are replicable in the UK market.

The Research Questions (RQs) posed by BEIS were:

- RQ1: Which countries have the most successful domestic energy efficiency retrofit supply chains?
- RQ2: How do domestic energy efficiency retrofit supply chains operate in different countries?
- RQ3: How do members of the domestic energy efficiency retrofit supply chain upskill in different countries?
- RQ4: How do consumers interact with the domestic energy efficiency retrofit supply chain?
- RQ5: How do the supply chains interact with central and local government regulation?

Methodology

The project was structured in two phases: a rapid evidence assessment and a deep dive into a small number of programmes or new business models.

Phase 1 - Rapid Evidence Assessment (REA)[1]: collation of the evidence in the literature related to domestic retrofit supply chains outside the UK. This used a defined search strategy developed from the Research Questions above. Peer reviewed (white) literature and high-quality grey literature were searched for using agreed keywords and exclusion and inclusion criteria; evidence was extracted and synthesised. This work was delivered between September and December 2019.

Phase 2 - Deep Dive: The published evidence drawn together in phase 1 had gaps and was insufficient on its own to answer the research questions. This phase comprised further, deeper analysis of relevant literature and interviews with experts, including academics and stakeholders from the buildings industries. The objective was to gain a deeper understanding of how the retrofit supply chain operates successfully in a small number of selected examples. The interviews were semi-structured and conducted using a topic guide. Relevant stakeholders were selected in consultation with BEIS; 13 interviews were held[2]. The findings from the

[1] An REA is a form of evidence review which aims to search and synthesise a large volume of information in a transparent and unbiased way. The REA undertaken in this project followed the “Defra NERC guide to scoping reviews and rapid evidence assessments”.
[2] With 14 stakeholders: one interview was held face to face with representatives from two different organisations involved in the same initiative

interviews and the additional literature research were then combined with the phase 1 results. This work was delivered between January and April 2020.

Key findings

The REA found only a small amount of published evidence: supply chain involvement in domestic energy efficiency retrofit is a relatively under-researched topic. It was not possible to identify from the published evidence any one country that had established a successful, self-sustaining approach that others could emulate. Instead, a range of generally small scale or short-term schemes exist in particular niches in a number of countries. Further research into a selection of these specific examples was carried out in phase 2. This supported the finding from the literature that no single country had established a successful, self-sustaining approach. The main findings from both phases are brought together under a series of key themes. These emerged from the phase 1 findings and were explored in more detail during phase 2.

Policy, economic and social factors supporting the development of energy efficiency retrofit activities

Policy, economic and social factors can set a supportive context or act as direct drivers for activities. There were few explicit mentions of any of these drivers in the reviewed literature. This could be because the authors are embedded in their own context and therefore have not considered explicitly how that context influences the retrofit activity they are describing. We asked interviewees whether there were factors that had supported their work, and most identified one or more that were significant.

Two particular elements that could support the development of retrofit activities were highlighted in the interviews. The first was a need for a stable regulatory framework over a significant period, perhaps of a decade or more, and potentially including financial commitment. The second was active engagement of the financial sector.

Direct drivers for energy efficiency retrofit which were mentioned included tackling fuel poverty, providing economic stimulus at a time of recession and wider climate or energy policy goals.

Stakeholders involved in energy efficiency retrofit activities

Householders were widely recognised as important stakeholders. The need to build their awareness and understanding was seen as an essential first step, followed by establishing trust in retrofit supply chains. Schemes and new market approaches are tackling this trust issue by using co-ordinators or contract managers who provide initial advice to the householder, connect them with quality assured installers, help them through the whole retrofit process and, in some cases, quality check the work. This not only builds greater trust, it can improve the householder's overall experience of the whole retrofit process. Householders remain reluctant to pay for initial advice, and many of the approaches studied here include detailed advice for householders that is free or heavily subsidised.

The need to change the way contractors and advisors[3] talk to households about energy efficiency is a strong message that has come out of this research. Contractors tend to talk

[3] Advisors include specific energy efficiency retrofit advisors and also more general project advisors such as architects or designers

about the efficiency improvements themselves and their potential to save energy. In contrast, there was a degree of consensus amongst interviewees that the key selling points for any energy retrofit work are; a beautiful, healthy home; physical comfort; and perhaps low energy costs or a more sustainable home.

Finance providers have played three roles in the retrofit process: increased provision of finance; incentivisation through lower cost finance; and referral of households to retrofit offers.

Other intermediaries, in particular trusted local networks such as trade groups, credit unions and community groups, are seen as essential to success in many programme-based approaches to retrofit. They provide routes to market and help schemes to overcome trust issues.

Engaging the supply chain in energy efficiency retrofit activities

In all the cases reviewed in this work, stimulation of demand and increasing/upskilling the supply chain have happened at the same time.

There is a high degree of consensus from the literature and the interviews that contractors, in particular smaller businesses, are not inclined to take on energy efficiency work. They are sufficiently busy with existing types of work and see a new area as unnecessarily risky. The solution to this problem has been a combination of funded training and devising low-risk opportunities for work, for example by passing on very warm leads to contractors. This essentially makes energy efficiency projects more attractive than other potential work opportunities.

Retrofit supply chains are fragmented. There are large numbers of small businesses and several may be involved in any one retrofit project. Co-ordination and integration of the various stages of project design and implementation, and of the work of the different tradespeople, are important for successful retrofit. However, there is not a single type of firm or job role within the supply chain to which these tasks are consistently assigned. Typically this means the whole task either doesn't get done at all, or it gets done partially and not very well. Energy performance can be significantly compromised as a result.

Two models have been seen to be effective to overcome these issues. The first is the multi-skilled team based on shared tasks, shared risks, and shared problem-solving. The second is the involvement of an effective 'integrator' to manage on-site teams and provide a link between the physical work being carried out, the technical demands of the energy targets in the design, and the interaction with the client.

A number of ways of collaborating across disciplines and roles to provide integrated renovation services have been identified, called by various names ('One Stop Shops' (OSSs) or 'Rescos', or 'consortia') or referred to as new 'business models' for integrated renovation services. The idea of a partnership approach[4] between an integrating organisation and contractors has been used in both the US Better Buildings Neighborhood Program and the Danish BetterHome service. In both cases this is thought to have been a successful way to engage contractors in an attractive offering to the householder.

[4] NB this refers to ways of working, rather than any formal partnership agreements

Training, skills and quality

Two core issues were identified relating to training, skills and quality in the UK. Firstly, there are no formal entry requirements for construction jobs in the UK, unlike for many professions and unlike for the construction industry in some other countries. Secondly, the sector is very fragmented, with work largely being undertaken by separate trades (plumber, electrician etc) and this leads to a lack of responsibility for overall quality control and assurance.

There were a number of points made about the format of construction training in the UK, linked to both of these core issues. An important distinction is between vocational education systems based on learning outcomes (the ability to complete specific tasks), as are used in the UK, and vocational systems based on standards for industry entry, which also include theoretical knowledge together with a broader understanding of industry processes and project management. A standards-driven approach is compatible with the need for good coordination and integration in retrofit, and it should build understanding that crosses conventional trade boundaries. Further, some construction training in the UK does not include low energy construction at all.

Large scale, centrally driven training programmes may need to be set up and funded if the necessary skills for delivery are lacking. Flexibility in programme funding rules may be needed so that programmes can tailor the type of training and amount spent on it to local market needs[5]. There is a need for caution in this approach however: if a scheme employs significant numbers of newly trained installers, the speed at which activity levels increase and the level of quality control need to be carefully managed, otherwise quality may be compromised.

Working in partnership with contractors is seen as a way to build skills and practices that will outlast a specific initiative. Also, a number of interviewees suggested that if the contractors see the overall scheme offering, including skills development, as of value to them, then making quality delivery a requirement for continued participation can itself drive quality installation.

Discussion of training needs has tended to focus on the technical skills needed to ensure quality installation of measures. However, this work has found that upskilling in how to sell energy efficiency retrofit to households is as important in both growing demand in this market and ensuring a positive customer experience.

Scaling up from niche approaches

Generating homeowner demand for deep retrofits and developing the supply chain to meet this can take many years. There are no examples as yet where niche approaches have scaled up significantly or have become self-sustaining, financially. Evaluation of the US Better Buildings Neighborhood Program suggested that a funded programme of its scale would need to run for up to 10 years to build a self-sustaining market. One scheme, the Energiesprong programme, is now operating at a scale of multiple thousands of net-zero retrofits in the Netherlands, but this follows significant public investment in those countries and market development over almost a decade.

In addition to financial support over an extended period, a number of possible drivers for upscaling were identified by interviewees: demonstrator homes lived in by effective

[5] Markets in different localities can vary in the housing stock (building type and physical condition), housing market (depressed or buoyant), the local installer base, employment markets and the previous retrofit schemes that have been implemented in those local markets. All of these factors will influence the design of a retrofit programme which is suitable and the training required to support it.

ambassadors; returning to an area where some work has been completed, having given time for the local community to see the results and understand the benefits, and engagement of finance providers.

Conclusions

The following conclusions can be drawn by relating the findings to the original research questions posed by BEIS:

“Which countries have the most successful domestic energy efficiency retrofit supply chains?”

This research found that there is little difference overall between countries; none are at anywhere near the retrofit rate that is needed; some have interesting new approaches but these remain niche, without a significant impact as yet on overall supply chains. Secondly, the sector is very fragmented, with work largely being undertaken by separate trades and this leads to a lack of responsibility for overall quality control and assurance.

“How do domestic energy efficiency retrofit supply chains operate in different countries?”

There are ‘local’ variations in supply chains – such as the degree to which some actors (e.g. manufacturers) are involved, the level of contractors’ training and the experience to date with energy efficiency retrofit. However, there are many common issues, most importantly the fragmentation of the contractor base, the lack of interest in changing their focus to energy efficiency retrofit and a limited capability for selling energy efficiency retrofit to householders.

“How do members of the domestic energy efficiency retrofit supply chain upskill in different countries?”

The level of professionalism varies widely between countries as does the degree of training on low energy construction. Most training is fragmented and not co-ordinated, limited in occupational range and geographical reach, with most courses at higher levels and catering to those with some existing technical training. Some larger schemes and smaller, market led initiatives are providing specific supply chain training, on technical matters and on sales and marketing.

“How do consumers interact with the domestic energy efficiency retrofit supply chain?”

Consumers are not interested in energy efficiency for its own sake; they are interested in improving their home, increasing comfort and saving money. They are much more receptive to sales pitches where the end results of a more efficient home is emphasised and sometimes presented as part of a wider improvement process. Finance providers and trusted community leaders are also able to generate interest. Consumers are concerned that measures will be right for them and anxious that the changes won’t deliver the expected benefits. Demonstration projects and offering certification or guarantees can allay their concerns.

“How do the supply chains interact with central and local government regulation?”

This wasn’t identified as a significant issue in either the literature or in interviews, beyond the ‘structural’ with, for example, the requirement in some countries for architects to be involved in all renovation. However, there was the suggestion from one interviewee that regulations requiring greater control of sub-contractors would increase quality.

Introduction

Context

Energy use in buildings is consistently identified as a sector with large potential for energy efficiency improvement, both internationally and nationally. However, there are structural barriers in the way the construction sector operates in the UK which make it particularly difficult to initiate lasting change[6].

The current UK energy policy landscape

The UK was one of the first countries to recognise and respond to the challenge posed by climate change. The Climate Change Act (2008) committed the UK to reducing greenhouse gas emissions by at least 80% by 2050 when compared to 1990 levels. In early 2019, the government committed the UK to a legally binding target of net zero emissions by 2050.

Homes currently account for just over a fifth of the UK's emissions. Much of this is associated with heating; the Committee on Climate Change (CCC) estimates that heating and hot water for UK buildings make up 40% of our energy consumption and the decarbonisation of heat is recognised as being both essential and highly challenging[7]. In its latest report on housing, the CCC offers a bleak assessment of the current situation, including: stalled emissions reductions in the housing sector; a recent history of abandoned or weakened policy; a persistent design-performance gap; an inadequate and ineffective compliance regime; skills gaps in the workforce; and inadequate resourcing of local authorities[8].

Government ambition

The Clean Growth Strategy sets an ambition to reduce emissions from homes while ensuring that everyone has a home that is comfortable, heathy and affordable to run. The objective is to ensure that Government policy encourages people to improve their homes where it is cost effective and affordable for them to do so: "Our aspiration is that as many homes as possible are improved to Energy Performance Certificate (EPC) Band C by 2035, where practical, cost-effective and affordable".

The English Housing Survey found that, in 2016, only 25% of owner-occupied homes were EPC band C or higher (3.7 million homes). Around 10.4 million homes were D or E rated and around 0.8 million F or G rated. This means that 11 million homes will need to be improved to band C by 2035 to meet this ambition. This equates to 625,000 homes every year, or 12,000 homes every day.

The Industrial Strategy Grand Challenges include an ambition to halve the energy use of new buildings by 2030 and to halve the cost of renovating existing buildings to a similar standard as these new buildings, while increasing quality and safety.

[6] UKERC (2019) Disrupting the UK energy system: causes, impacts and policy implications available: http://www.ukerc.ac.uk/publications/disrupting-uk-energy-system.html [accessed 30/08/19]
[7] Committee on Climate Change (2016) Next Steps for UK Heat Policy
[8] CCC (2019) UK housing: fit for the future? Committee on Climate Change: London https://www.theccc.org.uk/publication/uk-housing-fit-for-the-future/ [accessed 30/08/19]

Current policies and programmes

There are a number of existing policies and programmes that will contribute to meeting the ambition of as many homes as possible being EPC C by 2035. Central amongst these are the Energy Company Obligation (ECO), Minimum Energy Efficiency Standards in the private rented sector and the Each Home Counts review on consumer protection, installer standards and enforcement.

Energy Company Obligation (ECO)

Supplier obligations (currently the Energy Company Obligation (ECO)) are at the moment the principal instrument to reduce carbon emissions in the UK's housing stock. They have delivered a range of energy efficiency measures such as cavity wall insulation, loft insulation and boiler installations[9]. The current ECO (ECO3) offers funding under the Home Heating Cost Reduction Obligation, and suppliers must focus on measures that improve the ability of low income, fuel poor and vulnerable households to heat their homes[10].

Minimum standards in the private rented sector

The Energy Efficiency (Private Rented Property) Regulations introduced Minimum Energy Efficiency Standards (MEES) in the private rented sector from April 2018. These mean that landlords cannot legally rent out F or G rated properties unless they undertake energy efficiency works, or claim an exemption (of which there are many).

Each Home Counts review / PAS 2035/2030 Retrofit standards

The Each Home Counts review[11] was commissioned by BEIS. It recommended new codes of conduct and standards for installers, designers and assessors to improve retrofit quality, and also suggested work with the Construction Industry Training Board to improve workforce skills and knowledge. The resulting PAS 2035/2030 standard 'Retrofitting dwellings for improved energy efficiency' was published in June 2019.

Supply chain and whole house retrofit pilots

The BEIS supply chain pilots[12] aim to address the non-financial barriers to increased uptake of retrofit measures in the able-to-pay sector. The six projects within the pilot are focused on supply side barriers and on reducing the challenges that prevent consumers from implementing energy efficiency retrofit activities.

The BEIS Whole House Retrofit Innovation Competition aims to demonstrate cost reductions in deep home retrofits through economies of scale and scope[13].

[9] Mallaburn P & Eyre N (2014) Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. Energy Efficiency, 7(1): 23-41.
[10] https://www.ofgem.gov.uk/environmental-programmes/eco/about-eco-scheme
[11] Bonfield P (2016) Each Home Counts: An Independent Review of Consumer Advice, Protection, Standards and Enforcement for Energy Efficiency and Renewable Energy. BEIS and DCLG
[12] BEIS (2019) Selected demonstration projects: summaries: https://www.gov.uk/government/publications/energy-efficiency-improvement-rates-local-supply-chain-demonstration-projects/local-supply-chain-demonstration-projects-summaries
[13] BEIS (2019) Whole House Retrofit Innovation Competition Guidance: www.gov.uk/guidance/whole-house-retrofit-whr-competition.

Private Rented Sector (PRS) enforcement pilots

The BEIS PRS enforcement pilots are testing enforcement of the MEES regulations in seven local authority areas where there are large numbers of sub-standard private rented domestic properties. The overall objective of the pilots is to develop an understanding of how the regulations are currently being enforced. This includes gaining an insight into the challenges faced by local government, to help improve implementation and inform long-term policy making.

Building a Market for Energy Efficiency

Alongside these existing policies, BEIS has consulted on how to encourage households to invest in the energy efficiency of their homes[14]. Policy ideas continue to be developed following this consultation, including within the Green Finance Strategy[15].

Barriers to policy success

Most domestic energy efficiency initiatives have focused on those living in fuel poverty. The Green Deal, launched in 2013, was intended to stimulate the wider market but proved unattractive to private households and landlords. As a result, the programme stopped in July 2015 having issued only about 15,000 Green Deal loans over 2.5 years[16]. The scheme was relaunched in 2017 under private ownership; figures on the number of loans granted under the new scheme are not, to our knowledge, publicly available.

Progress on improving the UK's housing stock is currently too slow to meet the government's climate change targets[17]. It is clear therefore that some form of market intervention is still needed.

The 'Building a Market for Energy Efficiency' call for evidence (CforE) identified a number of barriers to improving energy efficiency on both the demand and the supply side. Supply side barriers include: the lack of the necessary skills to deliver retrofit, lack of industry coordination and a historic lack of long-term signals from government, which has reduced confidence to invest in the energy efficiency market and to invest in innovation and new services.

The UK supply chain and retrofit market

The CforE also stated that most energy efficiency measures involve changes to the fabric of properties and so should be viewed in the context of the wider market for home improvement. It noted that most households undertaking home improvements (79%) are planning to finance them through their savings, with 10% taking out a bank loan and a further 10% using a mortgage extension. 65% of British householders own the home they live in[18], and in 2017

[14] Building a market for energy efficiency: call for evidence, https://www.gov.uk/government/consultations/building-a-market-for-energy-efficiency-call-for-evidence
[15] https://www.gov.uk/government/publications/green-finance-strategy
[16] Rosenow J & Sagar R (2015) After the Green Deal: Empowering people and places to improve their homes. [accessed April 2020]
[17] See, for example, The Institution of Engineering and Technology in partnership with Nottingham Trent University (2018) Scaling up retrofit 2050: Why a nationwide programme to upgrade the existing housing stock is the only way for the UK to achieve its carbon saving goals https://www.theiet.org/impact-society/sectors/built-environment/built-environment-news/scaling-up-retrofit-2050-why-the-uk-needs-a-national-housing-upgrade-programme/ [accessed April 2020]
[18] ONS (2020) People in households by housing tenure and combined economic activity status of household members: Table 1 via https://www.theiet.org/impact-society/sectors/built-environment/built-environment-news/scaling-up-retrofit-2050-why-the-uk-needs-a-national-housing-upgrade-programme/ [accessed April 2020]

owner-occupiers in the UK collectively spent around £22 billion on repair, maintenance and improvement to their home[19].

Research has shown that there is untapped potential in 'trigger-point' opportunities to include energy improvements in other work offered by general home repairs, maintenance and improvements (RMI). Approximately 45% of the total RMI market value is estimated to be a good opportunity or 'trigger' for energy efficiency improvement, representing roughly £11 billion per year for all homes, and over £7 billion of private investment in owner-occupied homes[20]. Projects may be 'whole home' retrofits or done on an 'over time' or room-by-room basis[21]. It is equally true that these trigger points, if missed, mean that the opportunity can be lost for many years: it makes no sense to rip out a new kitchen in order to insulate the floor and walls, but the cost and disruption of the work is massively reduced when done at the same time as fitting a new kitchen. Pioneers of low-energy retrofit in the owner-occupied sector have shown the importance of seizing these opportunities when they arise[22].

RMI of owner-occupied homes is largely delivered by Small and Medium-sized Enterprises (SMEs) or sole traders[23]. These firms work at a very local level and have limited knowledge of energy efficiency or low carbon heat measures. They may not see the benefits of upselling energy efficiency as an add-on to their typical work and do not always have the skills or experience to do such improvements themselves[24]. Ambitious energy reductions from retrofit are possible, but the work requires a level of design integration and attention to detail on site which far exceeds normal industry practices[25].

SME construction firms do however have a significant influence on the design and specification of renovation projects, especially the smaller projects where there is not an architect or design professional involved[26]. Manufacturers in the construction supply chain are very aware of the influence of installers on householders and invest much time and money in trying to build installer brand loyalty[27].

The local nature of building trades' RMI activity indicates a good fit with local delivery of integrated energy efficiency schemes, including energy advice and assessments and community-scale awareness raising and partnerships[28]. However, while some builders may be keen to promote energy efficiency, they need support to overcome a trust barrier. They are wary of being seen to be selling unwanted extras to homeowners who have employed them on a particular refurbishment project[29]. In the vast majority of cases, consumers do not request

[19] Construction Products Association (2018) Construction Industry Forecasts 2018-2019, spring 2018 edition.
[20] Killip G (2011) Latent market opportunities for low-carbon housing refurbishment. Energy and People: Futures, Complexity and Challenges conference, University of Oxford.
[21] Fawcett T (2013) Exploring the time dimension of low carbon retrofit: owner-occupied housing. Building Research and Information, 42(4): 477-488.
[22] Fawcett T & Killip G (2014) Anatomy of low carbon retrofits: evidence from owner-occupied Superhomes. Building Research and Information, 42(4): 434-445.
[23] SMEs can be defined as businesses with fewer than 250 employees. The RMI market is dominated by firms that are at the smaller end of this definition, from sole traders to micro businesses with one or two other employees
[24] Maby C & Owen A (2015) Installer Power, the key to unlocking low carbon retrofit in private housing.
[25] Topouzi M, Killip G & Owen A (2017) Learning from 'horror' stories: a plan of work to reduce the performance gap in deep retrofit. Proceedings of 33rd Passive and Low Energy Buildings (PLEA) International Conference, 2nd-5th July 2017. Edinburgh, NCEUB.
[26] Owen A, Mitchell G & Gouldson A (2014) Unseen influence: The role of low carbon retrofit advisers and installers in the adoption and use of domestic energy technology. Energy Policy, 73. 169 - 179.
[27] Killip G, Owen A & Topouzi M (2020) Exploring the practices of UK construction manufacturers and merchants in relation to housing energy retrofit, Journal of Cleaner Production, 251.
[28] Maby C and Owen A (2015) Op. Cit. 24
[29] Energy Saving Trust (2010) Trigger Points: A Convenient Truth, Promoting Energy Efficiency in the Home

energy retrofit works and RMI building trades do not offer them. It is a vicious circle where no demand leads to no supply leads to no demand. Overcoming this requires both supply and demand to be stimulated at the same time. The 'trigger points' are not currently converting into retrofit projects, and opportunities to upgrade homes are not being taken by more than a tiny fraction of the market.

Learning from international comparisons

International comparisons typically provide a great deal of rich and useful information. In complex, real-world contexts, the evidence of things actually operating differently (better, worse or just otherwise) in a different location can help frame better questions about what might need to change in the UK.

BEIS recognises the importance of learning replicable lessons, acknowledging that what is needed or relevant in one context may not be transferable. For example, building types and climate regimes are two examples of contextual factors which could reduce the potential for direct transfer to the UK.

International comparisons do need to be conducted and interpreted carefully, because the context in which observations are made needs to be understood. There may be good reasons (cultural, political, socio-technical, economic) why practices that work well in one place may be less effective elsewhere[30]. The housing retrofit supply chain's relevant contextual factors include the social organisation of labour and labour market regulation; national systems of vocational training and education; housing tenure; regulatory minimum standards; compliance and accreditation regimes; and models of governance (between national, local and regional tiers of government).

The objective of the International Review of Domestic Retrofit Supply Chains is to learn lessons from other countries about retrofit supply chains that can help to guide the development of UK policy, leading to greater uptake of retrofit at reduced cost.

Research aims and objectives

BEIS commissioned this research project to bring together the relevant international evidence and create an overview of different domestic energy efficiency retrofit supply chain practices. The aim was to identify the factors leading to a successful retrofit supply chain and examine whether they are replicable in the UK market.

The Research Questions (RQs) posed by BEIS were:

- RQ1: Which countries have the most successful domestic energy efficiency retrofit supply chains?
- RQ2: How do domestic energy efficiency retrofit supply chains operate in different countries?

[30] The project has been conducted taking these considerations into account – for example, in the search strategy for the REA by excluding countries where the climate, economy or build type are not transferable to the UK and by asking interviewees explicitly about the policy / economic / social factors that supported the development of the schemes that they were discussing so that differences with the UK could be clearly identified.

- RQ3: How do members of the domestic energy efficiency retrofit supply chain upskill in different countries?
- RQ4: How do consumers interact with the domestic energy efficiency retrofit supply chain?
- RQ5: How do the supply chains interact with central and local government regulation?

Methodology

Overview

The project was structured in two phases:

- Phase 1 - Rapid Evidence Assessment (REA) [31]: collation of the evidence in the literature related to domestic retrofit supply chains outside the UK, using a defined search strategy developed from the Research Questions above. Peer reviewed (white) literature and high-quality grey literature was searched for using agreed keywords and exclusion and inclusion criteria; evidence was extracted and synthesised. This work was delivered between September and December 2019.
- Phase 2 - Deep Dive: further, deeper analysis of relevant literature and interviews with experts, including academics and stakeholders from the buildings industries. This was to a deeper understanding of how the retrofit supply chain operates successfully in a small number of selected examples. The interviews were semi-structured and conducted using a topic guide that was agreed with BEIS. Relevant stakeholders were selected in consultation with BEIS; 13 interviews were held (with 14 stakeholders). The findings from the interviews and the additional literature research were then combined with the phase 1 results. This work was delivered between January and April 2020.

The methodology is described in full in a separate technical report.

Phase 1

A search strategy for the REA was developed in consultation with BEIS. The full search strategy is included in the separate technical report. A summary is provided here:

- Keywords for the literature search were developed using the PICO (Population, Intervention, Comparator, and Outcome) model. These were refined as the project progressed[32].
- Inclusion and exclusion criteria were agreed.
- Evidence from the peer-reviewed (white) literature was sought using the database platforms Web of Science and Scopus.

[31] An REA is a form of evidence review which aims to search and synthesise a large volume of information in a transparent and unbiased way. The REA undertaken in this project followed the “Defra NERC guide to scoping reviews and rapid evidence assessments”.
[32] Examples of the terms used for each element of PICO are, respectively: Residential, Energy Efficien*, Europe and Market Penetrat*

- Evidence from grey literature was sought by use of internet search engine “Google” (using identified search strings) and specific searches of relevant institution websites (e.g. the Intelligent Energy Europe project database, CORDIS, US DoE Better Buildings, BPIE) and searches of the European Council for an Energy Efficient Economy (eceee) and American Council for an Energy Efficient Economy (aceee) conference paper databases. In addition, key contacts from the project team’s networks were asked for their suggestions of grey literature.
- Evidence was evaluated against the exclusion and inclusion criteria, initially by title and then by abstract.
- Evidence was extracted from the selected sources using standardised templates and rated for relevance and robustness using criteria which were defined for the REA question and evidence type (e.g. general, qualitative, review).
- The evidence was synthesised and summarised and conclusions drawn to inform phase 2 of the project.

Phase 2

The published evidence drawn together in phase 1 had gaps and was insufficient on its own to answer the research questions. As expected, further, more detailed research, was needed.

The original plan was to look in more detail at specific countries. However, the findings from phase 1 meant that we instead focussed on individual schemes, services or concepts, investigating the specifics of their successes, together with their limitations and failures. These offered examples of good practice that covered the project areas of interest and enabled the team to undertake in-depth study to identify useful and relevant insights for the UK domestic retrofit market.

Following a phase 2 inception meeting with BEIS in January, the project team compiled a list of key people to engage. These contacts were either people who were familiar with the literature and policy documents relevant to a country or scheme, or people working directly on the schemes, services or concepts. The list was drawn from the findings of the REA together with additional suggestions from the research team.

The team designed a topic guide based on the initial research questions and a series of themes that had emerged from the literature review. Fourteen stakeholders were interviewed. The list of interviewees and topic guide is included in the separate technical report.

The team also reviewed additional grey and white literature that was suggested by or provided by the interviewees. This helped to provide as complete a picture of activity as possible, including the context in which the supply chains operate.

The findings from the phase 2 research were then synthesised and considered alongside the findings from phase 1 and BEIS’s research questions. The results were then combined into this overarching project report.

The report has been externally peer reviewed by Dr Julie Gwilliam from Cardiff University.

Findings

In this section, the main findings from both phases of the work are brought together under a series of key themes. These had emerged from phase 1 and were explored in more detail during phase 2. The findings are then related back to the original research questions that the work was designed to explore.

Policy, economic and social factors supporting the development of energy efficiency retrofit activities

Policy, economic and social factors can set a supportive context for retrofit activities or can act as direct drivers for activities. A number of these were highlighted by the research. It is worth noting that there were few explicit mentions of any of these drivers in the reviewed literature. This could be because the authors are embedded in their own context and therefore have not considered explicitly how that context influences the retrofit activity they are describing. Interviewees were asked about contextual factors and most said that they were significant[33].

Supportive context

Two factors that could support the development of retrofit activities were mentioned in this research. The first of these was mentioned by two interviewees; the second was more frequently referred to, both by interviewees and in the literature.

The first factor is a general need for a stable regulatory framework over a period of a decade or more, potentially including financial commitment. For example, experience in Ireland shows that annually changing grant programmes can lead to programmes being quickly oversubscribed and hence to frustration amongst householders. This can result in bad publicity about the stop-start nature of the schemes. We did not come across an example of a ten year framework; the closest is the four year US Better Buildings Neighborhood Program (BBNP, see Case study B), which one interviewee and the formal review of the programme suggested would have been more effective if it had been extended to at least ten years.

A number of schemes mentioned in the literature and in interviews were started with some financial support, under various EU programmes. (This was funding for a novel approach or integrator role, separate to grant or loan funding for retrofit measures.) One such scheme is the Superhomes scheme run by Tipperary Energy Agency (see Case study A). However, several interviewees mentioned that, despite the wish/intention for these schemes to continue, relatively few[34] of these persisted for long once the funding ended.

[33] This was to identify the context in which schemes were operating to establish how transferable the findings were to the UK context.

[34] For example, the following schemes operated after initial funding was used:
1. Okatave, France (https://www.oktave.fr/qui-est-oktave/) - supported by Intelligent Energy programme.
2. RetrofitWorks, UK (https://retrofitworks.co.uk/) - functioning co-operative part funded by the H2020 INNOVATE project (ongoing).
3. SuperHomes, Tipperary Energy Agency, Ireland (under different scheme name) - part of H2020 Concerto project.

Note that at least two of these schemes still receive EU, national or local financial support from other projects.

Case study A: Tipperary Energy Agency

Tipperary Energy Agency has been co-ordinating owner-occupier deep retrofit in Ireland since 2008. The work has been delivered with support from EU H2020 projects, initially Concerto, more recently ELENA[1]. Work since 2015, on the SuperHomes Ireland scheme, aims to retrofit homes to an 'A' grade energy rating; average investment per home is about €40,000, with government funded grants of 35% of this cost available. The level of activity is currently around 100 homes per year. Currently most of these retrofits are in Dublin.

The motivation for the work is the delivery of sustainable buildings and a move away from oil heating. When TEA started work on retrofit, the economy was slow and hence it was relatively easy to attract contractors; more recently, with a better performing economy, it has been more difficult to attract contractors away from the new build market because retrofit is seen as more hassle given that a householder is in residence. The Energy Agency is the trusted intermediary between the householder and the contractor, and delivers an initial survey, system design, selection and sometimes training of contractors and quality control. The householder contributes towards this service, but there is a shortfall in funding which is covered by EU money and money from the Energy Supplier Obligation.

The Agency consider the scheme to be successful, as there is a high level of satisfaction amongst those investing in deep retrofits, and most homeowners now see the value of good energy performance. Key success factors include:

- The central role of the Energy Agency as a trusted intermediary, with a 10 year record of delivering the expected results from deep refurbishment projects.
- The existence of partial grant funding from government and support from the electricity supplier (who benefits from increased use of electrical heating and help in meeting Energy Supplier Obligation commitments).
- Collaborative working with installers and the development of a high level of trust. Installers are expected to deliver, but are helped if they hit difficulties and are offered advice on pricing, and training as needed.
- Raising awareness and increasing credibility of the scheme by carrying out retrofits in the homes of high profile environmentally-minded individuals such as the head of the National Trust and the head of Dublin cycling campaign, with press coverage and in some cases visits from politicians.

The key to building a sustained market is thought to be a stable and supportive regulatory framework and the biggest issue that the programme faces is that the level of funding available is too small (grant funding is used up early in the year) and policy is currently too short term to generate a retrofit eco-system.

[1]European Local Energy Assistance.

The second supportive factor identified is active engagement of the financial sector[35] [36] [37]. One observation is perhaps particularly pertinent in a UK context: one interviewee described how banks became a key stakeholder in one business-led service because they were looking for business models to help them respond to a sustained period of low or negative interest rates. Green finance was seen as a key option. The interviewee suggested that energy efficiency investments with performance guarantees could provide provable returns and so qualify for mechanisms such as green bonds. The potential roles for financial institutions are explained further in the section on stakeholders below.

Direct drivers

Various direct drivers for energy efficiency retrofit activity were found in the research.

There were many references to tackling fuel poverty[38] [39] [40] and a number of specific mentions of the use of government financial contributions[41].

At times of economic recession, building renovation has historically been seen as an economic priority for investment, more for the stimulus effect that this kind of work can have on jobs and economic growth than for the energy saving effects. These economic stimulus programmes are typically short-lived, with support being scaled back and withdrawn once the wider economic indicators show improvement. Economic stimulus programmes provided the impetus in a number of countries including the US[42] and Australia[43]. Case study B details one significant example of such a programme: the USA's BBNP. Case study E, on the Australian Home Improvement Programme, also concerns employment creation.

Energy efficiency policy goals such as France's national target for deep renovation of half a million buildings or dwellings per year, or the Irish Climate Action Plan target to bring all homes to Energy Rating A standard by 2030, were mentioned by interviewees as drivers, as was the Dutch government's innovation programme to drive improved energy efficiency standards.

Digitalisation was mentioned by one interviewee as a strong driver of the development of new business models such as BetterHome. It is enabling more cost-effective tailoring of solutions for households, more efficient and effective communication with contractors and project progress tracking. This highlights the importance of maximising access to data. Other interviewees referred to this more as an enabling factor, making it easier for consumers to find installers and installers to find each other.

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[35] Maneschi D (2013) Widening the scope? How intermediary actors can shape energy consumption. Proceedings eceee Summer Study on energy efficiency, 2367-2379.
[36] Vesta Conseil et Finance (2018) Inventory of best practices for setting up an integrated energy efficiency service package including access to long-term financing to homeowners. Extensive analysis of the existing energy efficiency services operators and long-term financing schemes. Innovate Horizon2020 Project
[37] Broc J-S, Trauchessec E & Milin C (2015) Revisiting the KfW and Green Deal programmes: it's not all about finance! Proceedings eceee Summer Study on energy efficiency, 321-331
[38] Kivimaa P & Martiskainen M (2018) Innovation, low energy buildings and intermediaries in Europe: systematic case study review. Energy Efficiency, 11, 31-51
[39] Vesta Conseil et Finance (2018) Op. Cit. 36
[40] Hawke A (2010) Review of the administration of the Home Insulation Program. Canberra, Australia: Department of the Prime Minister and Cabinet
[41]Thorne J (2003) Residential Retrofits: Directions in Market Transformation, ACEEE Report Number A038.
[42] Gillich A and Mohareb E (2018) Turning national retrofit policies into local action: examples from the US BBNP and the Canadian eco-energy programs, 1st International Conference on New Horizons in Green Civil Engineering, April 2018, Victoria, BC
[43] Hawke A (2010) Op. Cit. 40

Case study B: The US Better Buildings Neighborhood Program

The Better Buildings Neighborhood Program (BBNP) was a Federally funded programme in the United States, implemented via grants to 41 separate organisations and with activity in every US State. It ran from 2010 to 2014. Over the first three years, $508 million (£412 million) was distributed to the 41 schemes, resulting in upgrades to 99,071 homes and consequent annual fuel bill savings of over $60 million (£48 million), during the 3 year evaluation period. The level of retrofit varied with local context and consumer preferences, but on average the programmes delivered savings in excess of 15% for households.

The scheme was part of the stimulus package rolled out in the US following the 2008-9 financial crisis, and had a number of aims: to upgrade more than 100,000 residential buildings, to save consumers $65 million on energy bills annually, to reduce the cost of energy efficiency programme delivery and to create or retain 10,000 to 30,000 jobs. The detailed design of each of the delivery schemes was dependent on the local situation, including existing levels of knowledge and awareness of energy efficiency, previous retrofit activity, and the current level of energy efficiency of the housing stock.

The schemes were largely successful in delivering their aims, and the main factors considered to have contributed to this are:

- Responsiveness to the need to persuade local contractors to take on energy efficiency work in addition to their existing retrofit workload (for example by providing paid-for training and significant engagement with contractors through regular round-tables).
- Provision of sales training and other softer skills development for the supply chain, alongside technical training.
- Locally specific design, that varied during the course of the scheme based on regular engagement and discussions with the local retrofit supply chain.
- Best use of available financial resources through partnership with financial institutions that unlocked additional private sector finance and/or led to establishment of revolving loan funds.
- Use of work in the homes of community group leaders as local demonstrations of the work and the benefits it could bring, and wider use of social marketing.
- Hand-holding for householders, using energy retrofit co-ordinators.

The biggest shortcoming of the programme was its limited duration: evaluation of the programme found that the development of a sustained market for whole house renovations was highly unlikely to have been achieved within a three year period. The evaluation suggested that, had the funded local programmes continued for ten years, programme achievements would have been higher in later years, as grantees gained greater experience.

Stakeholders involved in energy efficiency retrofit activities

All the initiatives we looked at involved multiple stakeholders. A number of interviewees stressed the importance of local context in determining which stakeholders should ideally be involved. This includes prior levels of action on energy efficiency in the local area, which would determine the extent to which local contractor networks, for example, were already established. Local households' familiarity with energy efficiency measures is also important, as are the types of community intermediary that are available and trusted by the local population. This section contains information about each of the following stakeholder groups: households, the finance sector, and other intermediaries. The energy efficiency supply chain is considered in a separate section below.

Households

Households are of course central to all retrofit activities. The research findings include useful insights on how households can be engaged by retrofit offers and how the delivery of a retrofit project could be designed to be a positive experience for them.

Building awareness and understanding amongst households was a theme that appeared a number of times. In one programme described in an interview, this involved broadcast media together with more personal, local approaches. This combination was seen as important. It helped to generate initial demand for energy efficiency retrofit and also to ensure that the end result met householder expectations by ensuring that new technologies and systems were being used appropriately[44]. Case study B details one programme where significant effort in householder engagement was explicitly identified as a success factor. One interviewee from another programme suggested that the benefit of incentives for households was as much in the raised level of awareness they generate as in any financial contribution they provide.

Trust and transparency were highlighted as a key aspect of householder engagement. Trust is seen to be a problem in the sector; one interviewee linked this with vague promises by contractors and results that don't meet expectations. Concerns raised by householders interviewed during studies in the Netherlands and Finland included: poor transparency of quotes; concerns about advice from someone in the supply chain with vested interests, and lack of ability to confirm whether a completed installation was of good quality[45].

Schemes and new market approaches are tackling this trust issue and the overall householder experience of a retrofit project, using co-ordinators or contract managers. These people provide initial advice to the householder, connect them with quality assured installers, help them through the whole retrofit process and, in some cases, quality check the work. One such intermediary described their role as "*to remove frictions; to progress the homeowner from someone who thinks 'how can I improve my home?' to a happy homeowner who has invested in some improvements and is ready for more changes"*. Householders remain reluctant to pay for initial advice, and many of the approaches studied here include detailed advice for householders which is free, or heavily subsidised. Case study C details the BetterHome service, one example of an approach to improved householder engagement.

[44] Thorne J (2003) Op. Cit. 41
[45] De Wilde (2019) The sustainable housing question: on the role of interpersonal, impersonal and professional trust in low-carbon retrofit decisions by homeowners. Energy Research and Social Science, 51, 138-147

Case study C: removing barriers for consumers - BetterHome

The BetterHome service operates in Denmark and is also expanding to Sweden. It was set up in 2014 and, to date, has overseen €120 million (£105 million) of investment in energy efficiency in owner-occupied homes in Denmark. The average project size is around €50 – 70,000 (£44-61,000), delivering energy savings of between 30 and 70 per cent.

The business was originally established by four Danish manufacturers (ROCKWOOL, Danfoss, Grundfoss and Velux) who felt that it should be possible to grow the market for energy efficiency retrofit work, based on householders' desires for home improvement. Velux has since ceased to be involved, due to changing business priorities, but the others remain committed. The BetterHome service is funded by the companies, and is therefore free to householders and installers. The aim of the service is to engage home owners with energy retrofit by linking it with aspirations for a better home and then by making the process as smooth as possible. The service works in partnership with a network of 3,500 installers, the majority of which are very small businesses. The service provides end to end support for the householder, beginning with advice and the specification of the project and ending with a customer satisfaction focused discussion at the end. For installers, the service provides warm leads, education in new solutions, and training in sales skills and new areas such as digitalisation.

The supporting manufacturers consider the service to be a sustainable business model. Key success factors include:

- The willingness of finance providers to refer householders to the service, based on their view that this type of work is an attractive route to increased green loan / green bond business.
- The ability of the service to provide installers with very warm leads for well-specified projects: the conversion rate from initial conversation between the householder and the installer to a delivered project is over 90%.
- A householder-centred view, with a focus on selling the salient benefits of the retrofit and on ensuring customer satisfaction throughout the process.

The service remains very much a niche element of the overall refurbishment market in Denmark, but increased interest in sustainability and growing engagement with finance providers may change this.

The need to change the way contractors and advisors are talking to households about energy efficiency is a strong message that has come out of this research. Issues with contractors' ability and willingness to sell new elements of a potential project to the householder are considered in the section on training, skills and quality below. Here, the focus is on the messages that householders are interested in.

A number of interviewees noted that a deep retrofit is a hard sell and may only be considered when broader refurbishment work is being planned; there is therefore a need for flexibility in the offerings to households. There was a degree of consensus amongst interviewees on the key selling points for any energy retrofit work. These are that it contributes to the desired end

result of a beautiful, healthy home; of comfort; and perhaps of low energy costs or a more sustainable home. The idea of energy efficiency itself is not interesting to most households.

The finance sector

Finance providers have played three roles in the retrofit process: increasing provision of finance; incentivisation through lower cost finance; and referring households to retrofit offers.

Partnerships with financial institutions may enable a two-way flow of referral: banks can refer interested households to trusted delivery partners whilst retrofit project proposers can point households to banks that will offer finance for the project.

In the US BBNP (Case study B), over 90% of schemes reported partnerships with financial institutions. These partnerships increased the availability of finance by using government funds as loan loss reserves, revolving loan funds or interest rate buy-down approaches[46].

A number of examples were found where financial institutions offered preferential interest rates for loans linked to energy efficiency retrofit[47]. Their success in driving increased levels of activity varies, and there are no examples where this approach has resulted in renovation rates high enough to meet national targets.

A further possible advantage of working with the finance sector is that finance providers may require formal certification of quality. This can drive up quality and provide additional assurance to consumers.

Other intermediaries

Trusted local networks are seen as essential to success in many programme-based approaches to retrofit. These include trade groups, credit unions and community groups. They may be sustainability focused organisations, but equally can be groups that do not have any core focus on energy or housing, such as faith groups or parents groups[48]. Retrofits in the homes of respected community advocates and community leaders in the early months of a scheme can provide examples of the benefits of the work and encourage others in the community to take part. A number of the local BBNP programmes in the US took this approach, as did SuperHomes Ireland.

Local civic networks are not a focus for more market based schemes but, for any approach, local contractors may be important[49]. For example, several programmes within the US BBNP found that external programme employees were viewed as outsiders, whereas local contractors can use their networks to extend the reach of the programme in the community.

Both programmes and market based approaches see the value in the support of local government. This can raise general awareness in the community, help schemes build links with community organisations and, at a political level, show leadership in uptake of retrofit offers[50]. Some mention was made in interviews of national government information and advice provision, but there is not a clear picture of the extent to which this has driven action.

[46] Thorne J (2003) Op. Cit. 41
[47] Broc J-S, Trauchessec E & Milin C (2015) Op. Cit. 37
[48] Gillich A and Mohareb E (2018) Op. Cit. 42
[49] Ibid.
[50] Vito (2016) Regional process innovations for building renovation packages opening markets to zero energy renovations, REFURB, Deliverable D3.3 & D3.4 Involvement and organisation of the supply side.

Engaging the supply chain in energy efficiency retrofit activities

In all the cases reviewed in this work, stimulation of demand and increasing/upskilling the supply chain have happened at the same time.

There is a degree of consensus from the literature and the interviews that contractors, in particular smaller businesses, are not inclined to take on energy efficiency work beyond the minimum required by regulations. There are several reasons for this. Firstly, these contractors are typically busy enough with conventional RMI work, so they do not need to expand their workload, nor to devote unpaid time to being trained[51]. Construction SMEs are profit 'satisficers'[52] rather than profit maximisers, so this point holds true even where 'upselling' could in theory be financially rewarding to the contractor. Secondly, supply chain actors have a low level of awareness of the potential benefits of new retrofit technologies. Thirdly, contractors are the ones who will be called back to fix any problems, and so the idea of doing work that is new and unfamiliar can be seen as unnecessarily risky[53] [54] [55] [56]. Working in tried and trusted ways with familiar materials and technologies is a much lower-risk proposition than branching out into new methods and products. Nor is that risk only perceived, as retrofit does entail new and additional kinds of risk. The investment of time and effort in learning how to identify and manage these new risks can be a strong disincentive when an easier living can be made doing conventional projects instead.

The solution to this problem has been a combination of funded training and low-risk opportunities for work. In programme-based approaches, this has resulted from programmes generating leads for work and in some cases funding any necessary training, tools and equipment[57]. One market-based solution, BetterHome (Case study C), delivers very warm leads by providing initial advice and guidance to householders who have responded to social media advertising or whose banks have recommended retrofit to them, before the contractor is involved. This results in a greater than 90% conversion rate from initial contractor conversation with the householder to delivered project. BetterHome also provides training at no cost to the contractor.

Particular businesses respond positively to this combination of low-risk opportunities and upskilling for a number of reasons: some companies are more interested in different ways of doing things; some have green motivations; in the case of deep retrofits, some are attracted by the idea of well specified, larger projects without the high risks usually involved in bidding for such work; some recognise the benefit of access to streams of work over time, and some are attracted to the idea of being associated with a trusted brand. All these factors, individually or in combination, were mentioned by one or more interviewees.

[51] Training has to be seen to lead to some advantage in the job market for it to be considered worthwhile. Both the reviewed literature and interviewees reported that free training as an element of a retrofit programme or service made involvement in the programme / service more attractive to the supply chain.
[52] They are content provided that they are making enough profit to enable themselves and any employees to earn a decent living
[53] Thorne J (2003) Op. Cit. 41
[54] Pardalis G, Mahapatra K & Mainali B J (2019) Swedish construction MSEs: simply renovators or renovation service innovators? Building Research. & Information 48, 67-83.
[55] Cré J, Mlecnik E, Kondratenko I, Degraeve P, van der Have J-A, Vrijders J, van Dessel J, Haavik T, Aabrekk S & Paiho S. (2012) Developing an integrated offer for Sustainable Renovations. Retrofit 2012 conference, Manchester, UK.
[56] Nösperger S, Killip G. & Janda K. B. (2011) Building expertise: A system of professions approach to low-carbon refurbishment in the UK and France. Proceedings eceee Summer Study, 1365-1376.
[57] Gillich A and Mohareb E (2018) Op. Cit. 42; Hawke A (2010) Op. Cit. 40; Thorne J (2003) Op. Cit. 41

Co-ordination and integration of the various stages of project design and implementation, and of the work of the different tradespeople, are important for successful retrofit. However, there is not a single type of firm or job role within the supply chain to which these tasks are consistently assigned. Typically this means the whole task either doesn't get done at all, or it gets done partially and not very well. Energy performance can be significantly compromised as a result.

Two models have been seen to be effective to overcome these issues. The first is the multi-skilled team based on shared tasks, shared risks, and shared problem-solving. The second is the involvement of an effective 'integrator' to manage on-site teams and provide an important link between the physical work being carried out, the technical demands of the energy targets in the design, and the interaction with the client[58]. What is most important is that the integrator has good project management skills.

The possible range of actors found in some form of intermediary role is very wide, and the nature of the role is also varied, depending on the nature of the project and the other actors involved. It is suggested that an independent person is better suited to this role. An experienced project manager can operate effectively on low-carbon projects without being an energy expert (so long as more expert advice is available within the retrofit team or scheme). However, the reverse is not generally true: an energy expert with deep technical understanding but shallow project management skills cannot operate successfully on these projects. When interviewees were questioned further about the essential characteristics of a low-carbon refurbishment project manager the answer from was: 'it's about managing the interfaces'.

The two models are not mutually exclusive and the need for flexibility in the various contexts for retrofit may mean that some combination of both approaches will be necessary, depending on the circumstances of each project.

A number of examples of collaboration across disciplines and roles to provide integrated renovation services have been identified, called by various names ('One Stop Shops' (OSSs) or 'Rescos', or 'Consortia') or referred to as new business models for integrated renovation services. The OSS finds a niche market to act on because there is fragmentation both on the supply side and on the demand side[59]. On one hand, the clients that would like to undertake a building renovation project find that it requires information, expertise and complex project management. The client would have to deal with a large number of providers and suppliers, be aware of a large number of legal and regulatory requirements, administer a large number of certifications, and maybe even apply for grants, loans or other forms of financing. Besides being time-consuming, it is close to impossible for a regular citizen to make informed choices about the combination of possible solutions, timings and organisation. An OSS can take this decision process over from the client. There are a number of international examples of these new business model approaches, but none have yet reached self-sustaining scale. Possibly one barrier to greater uptake is the novelty of the approach.

The idea of One Stop Shops is explored further in Case study D.

[58] Killip G, Fawcett T, Janda K B, Beillan V & Nosperger S (2013) Building Expertise: industry responses to the low-energy housing retrofit agenda in the UK and France. Proceedings eceee Summer Study, 77-86
[59] Boza-Kiss B & Bertoldi P (2018) One-stop-shops for energy renovations of buildings, European Commission Joint Research Centre Science for Policy report.

Case study D: One Stop Shops

One Stop Shops (OSSs) are advisory, co-ordinating and quality checking services to help consumers with energy efficiency retrofits. BetterHome and Energiesprong (see case studies C and F) are in part One Stop Shops. Other examples were found in Belgium, Estonia, France, Germany, Ireland, Italy, the Netherlands, Portugal, Slovenia, Spain, and the USA.

This type of approach is thought to be successful in increasing consumer confidence in the retrofit process and in encouraging people who are initially thinking of only one or two measures to undertake a deeper retrofit.

There are a number of common elements across most of the One Stop Shops found in this work. These include: low or no cost initial assessment of the home and identification of improvement potentials; hand-holding through the tendering and installation stages of the project; post-installation contact with the householder for quality checking, finalising guarantees etc, and educating the householder about using, monitoring and maintaining new systems. Less common elements that were part of some, but not all, One Stop Shop approaches include: provision of performance guarantees; direct access to finance and/or financial incentives; and training for / partnership with installers.

Key success factors identified by one or more of the programmes reviewed included:

- Being local, with access to strong networks within the local market of installers who have good long-term relationships with residents.
- Being able to facilitate access to finance and potentially secure better rates.
- Standing beside the home owner throughout the process, offering a single point of contact, simplified language and understandable contracts.
- Experienced project managers and the use of digital solutions which facilitate good collaboration between the various actors in the renovation process.
- Reducing the risk to contractors, and hence increasing their willingness to take on energy renovation work, by undertaking a lot of the initial discussion with households that may or may not result in work being carried out.

The idea of a partnership approach with contractors is used in both the US BBNP (Case study B) and the BetterHome scheme (Case study C). In the US BBNP, many schemes included regular round-table meetings with interested contractors. These informed decisions on programme design alterations, which in some cases substantially changed things at the programme level across a three year period. The communication with contractors through round tables ensured that programme activity could be linked to their forward work planning and that consistency was maintained. It is seen as a key success factor for the programme, because it convinced contractors that the programme was a serious one, with longevity. Installers are seen as partners in the BetterHome approach, and contractors are offered simple tools to improve the customer journey (for example, reminders for timely billing) as well as training in new technologies and techniques.

Many of the approaches reviewed have focused on the installation end of the supply chain, but manufacturers are directly involved in BetterHome, funding and overseeing the programme. The Energiesprong approach includes working directly with manufacturers to reduce the cost of measures. One interviewee also mentioned manufacturers offering free training to installers, with a view to increasing their long term market.

Distributors are viewed both positively and negatively by different retrofit offers. On the one hand, they can be a vital partner in getting new technologies into the market and familiarising installers with these new options. A review of the role of distributors in efficiency programmes in the US found that they can positively influence uptake by stocking more efficient products, through outreach to contractors and through contractor training. They can also provide market insight to programmes and hence enable fine-tuning of offers to consumers[60]. Indeed, another review of US utility-funded programmes found that in schemes providing incentives to distributors rather than directly to consumers, sales of energy efficiency products increased by between 50 and 100 per cent[61]. On the other hand, one interviewee suggested that the mark-up on products that distributors charge may be something that larger scale schemes want to circumvent.

Architects and designers have a role in deep retrofits, but there has been little mention of them in this work, other than for PassivHaus, where they are a primary focus of the approach, and in Belgium where they are legally required to be involved[62].

Training, skills and quality

Two core issues were identified relating to training, skills and quality in the UK. Firstly, there are no formal entry requirements for construction jobs in the UK, unlike for many professions and unlike for the construction industry in some other countries where training is closely linked to the regulation of entry requirements[63]. Responsibility for training for construction in the UK is devolved to the level of the individual worker or firm. This can result in people working in construction with no training at all.

Secondly, the sector is very fragmented, with work largely being undertaken by separate trades (plumber, electrician etc) and this leads to a lack of responsibility for overall quality control and assurance[64] [65] [66]. One interviewee stated that in some countries the responsibility for quality assurance of retrofit is explicitly assigned, although to a range of different organisations: in Scandinavian countries union representatives often take this role; in Germany

[60] Foster R, Grevatt J, Lange N and Gee T (2012) Efficiency Programs and Distributors: Opportunities to Fully Leverage the Supply Chain for Greater Impacts, Proceedings ACEEE Summer Study on Energy Efficiency in Buildings.
[61] Bickel S, Burns E, Rivett B, Vida D, Nelson M, and Parsons J (2016) Swimming to Midstream: New Residential HVAC Programs Models and Tools, Proceedings ACEEE Summer Study on Energy Efficiency in Buildings.
[62] Mlecnik E, Straub A & Haavik T (2019) Collaborative business model development for home energy renovations. Energy Efficiency, 12, 123-138.
[63] Clarke L, Gleeson C, Sahin-Dikmen M, Winch C & Duran-Palma F (2019) Inclusive Vocational Education and Training for Low Energy Construction (VET4LEC) Final report and Country Summaries, European Construction Industry Federation (FIEC) and the European Federation of Building and Woodworkers (EFBWW).
[64] Brown D, Kivimaa P & Sorrell S R (2018) How Can Intermediaries Promote Business Model Innovation: The Case of 'Energiesprong' Whole-House Retrofits in the United Kingdom (UK) and the Netherlands.
[65] Killip G, Fawcett T & Janda K B (2014) Innovation in low-energy residential renovation: UK and France. Proceedings of Institution of Civil Engineers: Energy, 167, 117-124.
[66] Murto P, Jalas M, Juntunen J & Hyysalo S (2019) The difficult process of adopting a comprehensive energy retrofit in housing companies: Barriers posed by nascent markets and complicated calculability, Energy Policy 132.

the Works Council, in France the Comité d'Entreprise. This is not the case in for construction in the UK where generally no one person or organisation is assigned responsibility for quality control, outside the very large, critical infrastructure projects covered by NAECI[67]. (Another model for addressing the quality issue, using an integrator, is described above.)

There were a number of points made about the format of construction training in the UK, linked to both of these issues. An important distinction is between vocational education systems based on learning outcomes (as in the UK), and vocational systems based on standards for industry entry. In the former, learning is predominantly focused on practical skills and the completion of relevant tasks, often narrowly defined in terms of job roles (e.g. what does a carpenter need to be able to do?). In the latter, the teaching of practical skills is complemented with formal learning about construction as an integrated process, leading to outcomes (e.g. what does a carpenter need to know to ensure that their work contributes to a good result?). A standards-driven approach is compatible with the need for good coordination and integration in retrofit, and it should build understanding that crosses conventional trade boundaries[68]. Further, some construction training in the UK does not include Low Energy Construction (LEC) at all. Also, one interviewee asserted that if the state led construction training, including responsibility for work placements, as in Belgium, this would make training a more attractive option and could increase numbers and the diversity of people taking up training offers[69]. They also stated that at present in the UK most work placements, an essential part of training both in and out of apprenticeships, are only open to those who have existing contacts in the industry.

One example of good practice which was cited by an interviewee is Glasgow City Building's training centre, where training includes on-site work on public buildings. Another good model of LEC training which was quoted was BC (British Columbia) Insulators[70], a Canadian trade union): their members have to be Red Seal-certified (a Canadian National program[71]) and take a four year program at the British Columbia Institute of Technology, which includes 720 hours of theory and classroom time and 6000+ hours of on the job training.

The Governance of Vocational Education and Training (VET) differs across countries. VET is constantly evolving in light of new technologies, techniques and societal goals. Managing and guiding this constant evolution is a task which many countries, such as Belgium, Germany and Italy, assign to a range of 'social partners'. These include government at different levels, businesses and trade associations, trade unions, consumer groups and technical experts[72]. This sharing of oversight amongst these stakeholders is intended to reduce the risk of one stakeholder dominating over others. In the UK construction sector, not all of these stakeholders are involved in VET governance. The role of organisations such as trade unions, consumer representatives and Non-Government Organisations (NGOs) has diminished, leaving the governance of VET largely in the hands of senior industry members, with arm's length oversight from national government.

Evidence from the FIT-TO-NZEB Horizon 2020 project details how training programmes have been developed to take place within vocational training centres, where models of deep retrofitting are available and hands on experience is provided, or to be delivered on the

[67] National Agreement for the Engineering Construction Industry, see https://www.njceci.org.uk/national-agreement/
[68] Clarke L, Gleeson C, Sahin-Dikmen M, Winch C & Duran-Palma F (2019) Op. Cit. 63
[69] For statistics of the very low number of women involved in the UK construction industry see Clarke, L., Gleeson, C.P. and Wall, C. 2017. Women and Low Energy Construction in Europe: a new opportunity? in: Griffin Cohen, M. (ed.) Climate Change and Gender in Rich Countries: Work, Public Policy and Action Earthscan. pp. 55-69
[70] http://insulators118.org/.
[71] http://www.red-seal.ca/about/pr.4gr.1m-eng.html.
[72] Clarke L, Gleeson C, Sahin-Dikmen M, Winch C and Duran-Palma F (2019) Op. Cit. 63

construction sites of deep retrofit projects where it is more convenient for workers to attend and where the opportunity may arise to solve 'real problems'. The programme has also designed different lengths of courses depending on the knowledge and skills of the workers involved. Full time training amounts to 40 hours, whereas upskilling courses are between 16 and 24 hours, and validation, which focuses on the skills and knowledge of experienced workers, amounts to 12 hours.

Large scale, centrally driven training programmes may need to be set up and funded if the necessary skills for delivery of large scale retrofit programmes are lacking. Flexibility in programme funding rules may be needed to facilitate this, so that programmes can tailor the type of training and the amount spent on it to local market needs[73].

There is a need for caution in this approach however: the speed at which activity is increased and the level of quality control need to be carefully managed if a scheme is employing significant numbers of newly trained installers, otherwise quality may be compromised. In the case of an Australian national scheme with the twin aims of employment generation and energy performance improvement, the establishment of standards and the provision of training did not prevent concerns about quality that eventually led to the closure of the programme[74]. Case study E provides more detail on this scheme.

Case study E: The Australian Home Insulation Programme

The Home Insulation Programme (HIP) was an Australian Government programme that was operational from 1st July 2009 to February 2010. The programme installed insulation measures in over 1 million homes but was closed down after over 100 house fires were linked to the installations and 4 contractors died.

The programme had twin objectives: 1) generating an economic stimulus and supporting jobs/small businesses and 2) improving the energy efficiency of homes. It was designed to provide easy access for lower skilled employees and resulted in accelerated development and deployment of training schemes. There were a number of positive elements within the scheme, in addition to the high number of successfully insulated homes. In particular, innovative cross-government working was noted, including the use of well-developed Medicare systems to administer rebates and collaboration with the Department of Education, Employment and Workplace Relations on training and employment opportunities.

The major issue for the programme was the unexpectedly high level of demand generated in a short time, which exposed failings in five key areas: programme governance; design and administration; risk management; inadequate regulatory frameworks (by State) and capacity. Early assumptions were that the programme would result in around 90,000 installations per month but, at its peak (November 2009) the number of householder submitted claims for reimbursement were almost double this, at 176,000. This put pressure on the staff administering the scheme and the compliance and audit mechanisms were unable to remove non-compliant installers from the programme register quickly enough.

[73] Research into Action (2015) Evaluation of the Better Buildings Neighborhood Program. Final Synthesis Report, Volume 1, DOE/EE-1202, prepared for the US Department of Energy Office of Energy Efficiency and Renewable Energy.
[74] Hawke A (2010) Op. Cit. 40

Working in partnership with contractors is seen as a way to build skills and practices that will outlast a specific initiative. Also, a number of interviewees suggested that if the contractors see the overall scheme offering, including skills development, as of value to them, then making quality delivery a requisite for continued participation can itself drive quality installation. Options for quality control mentioned in phase 2 interviews included regular check-ins with customers and tracking how any customer complaints are dealt with, and also working with banks who require quality assurance certification for the provision of loans.

Discussion of training needs has tended to focus on the technical skills needed to ensure quality installation of measures. However, this work has found that upskilling in how to sell energy efficiency retrofit to households is as important, both to grow demand in this market and to ensure a positive customer experience[75] [76]. This sales related upskilling has also, usefully, included training in communication and inter-personal skills for contractors discussing loans and financing with households[77]. Some interviewees said that providing these skills, and also those required as things become more digitalised, can encourage contractors to participate in energy efficiency retrofit initiatives.

One final point that was made in several interviews regarding ensuring quality outcomes was that deep retrofit processes should include educating the householder in how to use new technologies and systems appropriately.

Scaling up from niche approaches

Generating homeowner demand for deep retrofits and developing the supply chain to meet this can take many years. There are no examples as yet where niche approaches have scaled up significantly. Evaluation of the US BBNP (Case study B) suggested that a funded programme of its scale would need to run for up to 10 years to build a self-sustaining market.

The Energiesprong programme (see Case study F) is now operating at a scale of many thousand net-zero retrofits in the Netherlands, but this follows significant public investment and market development over a period of almost 10 years within a general market context that is considered more favourable than that in the UK[78].

BetterHome is viewed by the companies that fund it as sustainable, but at present remains niche, generating activity at a level of hundreds of deep retrofits per year in Denmark.

In addition to financial support over an extended period, a number of drivers for upscaling were identified by interviewees during phase 2 of this work:

- Demonstrator homes lived in by effective ambassadors can drive activity at a local level.

[75] Gillich A and Mohareb E (2018) Op. Cit. 42
[76] Ferguson J, (2018). The State of the Energy Efficiency Workforce in Rural America, Proceedings ACEEE Summer Study on Energy Efficiency in Buildings.
[77] There was no evidence collected in this project to suggest that this training was provided by financial institutions; rather it was provided by scheme co-ordinating organisations
[78] Differences in the Netherlands from the UK situation identified by an interviewee included: higher energy costs, increasing the value of energy savings; fewer low income households and a higher capacity to invest in improving affordable housing; a greater willingness on the part of government to structurally invest in energy efficiency.

- Returning to an area where some work has been completed, having given time for the local community to see the results and understand the benefits, can result in additional activity in that area.
- Engagement of finance providers may be key to significant scaling up.

Case study F: Energiesprong

Energiesprong is a net zero carbon whole house refurbishment and new build standard, funding mechanism and performance guarantee. The concept enables households to invest future energy and maintenance savings in upgrading homes, delivering homes that are comfortable, aesthetically pleasing and with guaranteed, low energy costs.

The approach was first implemented in 2009 in the Netherlands, with funding from a Dutch government innovation programme; it has now expanded to Germany, France, northern Italy, the UK and the USA (New York state and California).

Initial funding for market development teams was secured from the Dutch government (€40million), the German government (€6million), the French government (€11million), Provinces in Northern Italy (€2.3million) and the Greater London Authority (GLA) (€3million). Over €10million has also been secured from the European Union (EU).

In addition, investment support for pilots further supports the roll out of Energiesprong in these markets. There is great variation between the different countries that Energiesprong operates in. For example, the German government gives a 40% investment support incentive (with no budget cap), plus the provision of low-cost finance on Energiesprong's performance levels, whereas the French government hasn't committed to significant national investment grants to date. In the UK, BEIS has supported Energiesprong with €9million for two demonstration projects.

Energiesprong is not primarily positioned around energy efficiency, rather it is about bringing housing into the 21st century. This ensures the solutions are designed with a wider appeal.

The programme works with social housing providers to build pipelines and with construction companies, architects, designers and component manufacturers to build a package of retrofit measures to fit the different housing archetypes.

The Energiesprong team consider the programme to be successful, as evidenced by the growing pipelines for refurbishments in all countries in which the programme operates. Key success factors include:

- The level of government support. In the Netherlands this included €40 million for the programme and also direct support for two consortia of construction companies and component suppliers. Scale is essential for cost-effective delivery and this initial government support allows the concept to be proven and the pipeline to develop.
- The use of performance guarantees, linked to a focus on the quality of retrofits.

Summary and conclusions

BEIS commissioned this research project to bring together the relevant international evidence and create an overview of domestic energy efficiency retrofit supply chain practices in different countries. The aim was to identify the factors leading to a successful retrofit supply chain and examine whether they are replicable in the UK market. The work was undertaken in two phases: a Rapid Evidence Assessment and a deeper investigation of specific schemes using stakeholder interviews and additional literature review.

The REA found only a small amount of published evidence: supply chain involvement in domestic energy efficiency retrofit is a relatively under-researched topic. No single country was found to have established a successful approach that others could emulate; instead a range of generally small scale schemes exist in particular niches in a number of countries. Further research into a selection of these specific examples was carried out in phase 2.

The following conclusions can be drawn by relating the findings to the original research questions posed by BEIS:

“RQ1: Which countries have the most successful domestic energy efficiency retrofit supply chains?”

- There is little difference overall between countries; none are at anywhere near the retrofit rate that is needed; some have interesting new approaches (Energiesprong, BetterHome; French OSS, some ‘local’ initiatives in the USA, etc) which are experiencing success in terms of delivering deep retrofits that customers are happy with, but these remain niche without a significant impact as yet on the overall supply chains. Few of the schemes are financially self-sustaining (in terms of funding the integrated approach; separate from grant or loan funding for measures installed).

“RQ2: How do domestic energy efficiency retrofit supply chains operate in different countries?”

- There are examples of a wide range of retrofit measures referenced in the literature and the interviews; many of the schemes are focused on deep retrofit and Nearly Zero Carbon. Measures include all types of insulation (cavity wall, external wall, floor, ceiling/loft, window and door replacement) and many types of replacement heating technology (air and ground source heat pumps, combined heat and power (CHP), district heating, solar thermal) plus photovoltaics (PV)). There appear to be the skills to install these successfully in the particular circumstances, under particular schemes.
- There are ‘local’ variations in supply chains[79] such as:
    - the degree of involvement that some actors take, such as architects, manufacturers and finance providers; the level of training of contractors and the degree to which this training provides the skills and knowledge required for successful retrofit on a large scale.
    - the degree to which previous schemes have been successfully carried out.

[79] These are described in Appendix A.

- However, there are many common issues, foremost of which are:
    - fragmentation of the contractor base. Most companies are very small, with 1-4 employees, which leads to a low capacity to both innovate and scale up.
    - a lack of interest in changing their market to renovation – particularly when (as in most circumstances outside of recessions) there is more than enough demand for 'regular' building work, or 'simple' single measure retrofit.
    - limited capability for selling energy efficiency retrofit.

"RQ3: How do members of the domestic energy efficiency retrofit supply chain upskill in different countries?"

- There is more professionalism in some countries - basic entry into construction requires a certain level of qualifications.
- In some countries the social partners for oversight of vocational training development include not just employers but also worker representatives (Trades Unions, Works Councils etc) consumer representatives and NGOs. A broad social partnership can help focus strategy on long-term objectives and wider societal goals.
- In some countries all building training includes material on low energy construction, but for most it is lacking or limited.
- Most training is fragmented and not co-ordinated, limited in occupational range and geographical reach, with most courses at higher levels and catering to those with some existing technical training.
- Some larger schemes and smaller, market led initiatives are providing specific supply chain training – both technical and on sales and marketing.

"RQ4: How do consumers interact with the domestic energy efficiency retrofit supply chain?"

- Consumers are not interested in the idea of energy efficiency itself – they are interested in improving their home, increasing comfort and saving money, including through the use of energy efficiency measures. They are much more receptive to sales pitches along these lines.
- Consumers are concerned that installers will try to sell their system/equipment whether or not it is right for them.
- They are also anxious that the changes won't deliver the benefits that they have been promised. Offering certification and/or guarantees can allay their concerns.
- Consumers are nervous about deep retrofit due to the degree of disruption from the process and having to deal with new technology. Some schemes have addressed this using demonstration projects in the local area or work undertaken for high profile individuals showing what can be done, and by making the process as simple as possible for them (removing choices) [80] or providing flexible options such that customers can take a step by step approach. Several schemes used trusted intermediaries giving a single point of contact and 'hand holding' through the whole process.

[80] For example, Tipperary Energy Agency (TEA).

- Finance providers (who appear to be widely trusted) and trusted community leaders are two possible ways to generate interest.

“RQ5: How do the supply chains interact with central and local government regulation?”

- This wasn’t identified as a significant issue in either the literature or in interviews, beyond the ‘structural’ with, for example, the requirement in some countries for architects to be involved in all renovation. However, there was the suggestion from one interviewee that regulations requiring greater control of sub-contractors would increase quality.

Appendix A: Phase 1 REA findings

This appendix describes findings from phase 1 of the project – the Rapid Evidence Assessment (REA).This phase of the research aimed to bring together the relevant international evidence to create an overview of different domestic energy efficiency retrofit supply chain practices.

A search strategy was implemented for the three primary questions agreed with BEIS:

- REAQ1 *"What is the evidence of the influence of the supply chain on the success of domestic energy efficiency retrofit?"*
- REAQ2 *"What is the evidence of how supply chains for domestic energy efficiency retrofit operate outside the UK?"*
- REAQ3 *"How do members of the domestic energy efficiency retrofit supply chain upskill in different countries?"*

The evidence which was found was:

- Very sparse (particularly for REAQ1).
- Mostly not written with a focus on the supply chain – rather the supply chain tended to be seen as a subsidiary issue to the main question being investigated; often this was wider 'green building' issues (REAQ1 or REAQ2) and/or socio-economic aspects (REAQ3).
- About schemes operating within particular support mechanisms – programmes, loans, tax breaks etc.
- Mostly in Europe (predominantly in the EU); with some examples from the USA, Canada and Australia.
- Illustrative of supply chain innovations at regional or local (not national) level, and not identifying a particular success story in any one country.

The findings of the REA

The scale of the challenge and responses to it

There are several noteworthy and successful initiatives described in this REA. However, whilst several countries have made strides forward in developing markets for ambitious, good quality retrofit, none has yet seen the full-scale market transformation that is demanded by the targets and timescales set out in climate policy. Overall figures on the rate and depth of retrofits, compared with relevant climate target requirements, are seldom reported in the detailed evaluation of each retrofit initiative. However, it is usually possible to deduce that the achievements being reported are several orders of magnitude below what is needed. Even the best, most innovative examples described here are partial solutions.

The importance of context

Each national context is different - for policy and industry - so caution is needed in interpreting findings.

Evidence is limited by supply chain interest in energy efficiency retrofit

- Supply chain awareness of the potential for energy retrofit is low.
- Market actors can largely ignore (energy) retrofit because they have plenty of work in the healthy and mature market for repair, maintenance and improvement (RMI) or in new build developments.

Specific evidence relating to the influence of the supply chain on the success of domestic energy efficiency retrofit (REAQ1)

- Installer training, certification and licensing are all important.
- Contractors need help incorporating retrofit into their normal market offer.
- Consumer incentives do not work if unaligned with installers' motivations.
- Engaging with contractors, especially small firms, is challenging but essential.
- Distributors and manufacturers can help shape supply chains.
- Incentives for supply chain actors can increase consumer uptake and satisfaction.
- It is important to work with, and not against, existing local installer networks.

Specific evidence relating to how supply chains for domestic energy efficiency retrofit operate outside the UK (REAQ2)

- Supply chains include market actors of various types. This includes: manufacturers, distributors, merchants and designers, as well as on-site construction firms.
- Fragmentation in the supply chain makes things difficult. Coordination and integration of project design and delivery are both important, but these tasks are not assigned clearly and regularly to any market actor at present.
- There are risks, for market actors and for policy makers, of doing retrofit wrong or badly.
- Supply chains include market actors of various types. This includes: manufacturers, distributors, merchants and designers, as well as on-site construction firms.
- Demand and supply must be stimulated simultaneously since training installers will not create demand and incentivising end-consumers will not create competent installation teams.
- Installers are very influential over consumer decisions at project level.
- Novel business models do exist, addressing many of the issues - but they are a very small percentage of the wider industry/market.

- No country has so far successfully merged the markets for energy retrofit and general RMI.

Specific evidence relating to how members of the energy efficiency retrofit supply chains upskill in different countries (REAQ3)

There are many variations in training in the different countries for which evidence was found. These occur in:

- Labour market regulation.
- Governance of Vocational Education and Training (VET) and involvement of social partners.
- Levels of qualification and time spent studying.
- Initial versus continuing VET.
- Classification of VET (not typically energy-related).
- Quality of evaluation of learning outcomes.
- Numbers in training (if reported).

Flow of evidence

Table 1 shows the flow of evidence in the REA from initial search to evidence extraction.

Table 1: Flow of evidence in REA

Category	Items found	Relevant on title	Relevant on abstract	Evidence extracted
White literature*	6373	131	26	23
Grey literature	NA	316	43	31

* some overlap between research questions

Table 2 shows the evidence synthesised for each REA question.

Table 2: Evidence synthesised for each REA question

Category	REAQ1	REAQ2	REAQ3	Total**
White literature	3	16	2	22
Grey literature	5	15	11	30
Total	**8**	**31**	**13**	**52**

** some overlap between research questions

REAQ1 evidence synthesis: primary question

"What is the evidence of the influence of the supply chain on the success of domestic energy efficiency retrofit?"

Evidence base characteristics

Relatively few (8) pieces of evidence were found which were relevant to this topic, all dating from between 2003 and the present. There was no evidence on the 'general' building supply chain, with all but one source relating to energy efficient/green/Nearly Zero Energy Buildings (NZEB) renovation[81] . All the evidence related only to domestic buildings.

The split of sources by country is shown in Table 3 below. (NB one study included described more than one country, so the total is more than 8).

Table 3: Evidence synthesised by country for REAQ1

Country	Number of grey sources	Number of white sources
Australia	1	0
Canada	1	0
EU	0	1
Finland	0	1
Netherlands	0	1
USA	4	0

Five of the studies reviewed regional or national energy efficiency renovation incentive schemes. They had a particular focus on how involvement of the supply chain had affected the success of the schemes. Three of these five studies related to a particular technology (HVAC or roof insulation) and two were concerned with whole house retrofit. Four of them consider the involvement of the supply chain a success, one flagged what can go wrong.

Two of the studies looked qualitatively at two specific examples of the interaction of customers and the supply chain, in the Netherlands and Finland, and how this could be improved.

Finally, there was a systematic literature review of closely related topics including innovation, low energy buildings and intermediaries. This contained only limited evidence of direct interest[82], but it did demonstrate that other authors have also found little evidence relating to this question.

The evidence is presented below in three groups: reviews of regional or national incentive schemes; reviews of consumer interactions with supply chain actors; and systematic reviews:

[81] Another 6 also covered new build.
[82] However relevant references were added to the evidence base for this REA.

Reviews of regional or national incentive schemes

Thorne, 2003, reviewed case studies of eight system specific or whole house (funded) programmes in the USA.

The approach taken[83] in each programme was considered and a broad assessment was made of the scheme's success and the factors affecting it. The outcomes considered included the uptake by contractors; the uptake by consumers; the closure rates for contractors (conversion from sales contact to the work being commissioned); the number of people trained; the number of certified contractors involved; and the average savings per consumer.

Key lessons to date were summarised as:

- Initial efforts to build an infrastructure for quality residential retrofit services must target contractors. Training, certification, and licensing requirements are all important and effective tools in ensuring a pool of contractors who have the necessary skills and experience to perform the high-quality work that is needed to deliver energy savings, improve home performance, and build customer confidence.
- Consumer education is also needed to build lasting demand and transform the market. Consumers must understand the benefits of comprehensive home energy improvements, including greater comfort, improved home safety and lower energy bills, before they will demand these services.
- Reducing the risk to contractors of offering home energy performance services can be very important in encouraging them to take the first steps into the business. Strategies that have been used successfully include: offering financing or other help with the purchase of necessary tools and equipment; providing strong marketing leads; and giving compensation for the time it takes to establish relationships with other contractors and make the necessary referrals.
- Consumer rebates can be a helpful tool to attract homeowners' attention, but they cannot be the centrepiece of a program or its main element. Without adequate consumer education and attention to building a strong contractor base, rebates will not lead to a sustainable demand for effective home energy retrofits or create the infrastructure to provide these services.
- Important factors in generating consumer interest and confidence in the expected results of a retrofit project include: a clear energy analysis based on a thorough assessment of the home and the energy usage patterns; recommended measures based on the analysis; trained contractors that know not only how to perform quality work but also how to sell quality to consumers; and clear information on recommended options, contractors and financing, to help consumers through the decision-making process.
- With creativity and flexibility, programme implementers can develop successful home retrofit strategies to fit different programme budget levels, resource constraints, and market conditions.
- While there has been progress, some persistent challenges remain. Engaging smaller contractors continues to be difficult for many programme operators. Convincing

[83] Whether or not the house was energy rated, what technologies were included, the form and amount of any customer incentive, how contractors (the supply chain) were involved.

contractors to pursue their own broader marketing efforts has been a problem; however, this is an important step in market transformation and is vital for programmes operating with very small budgets. As noted above, no specific strategy for addressing smaller contractors had been developed.

- Contractors need help incorporating new practices into their business models. With the value-added services inherent in the whole-house approach, contractors will almost always charge more for some services. The key is communicating the additional benefits to consumers and competing on the basis of comprehensive and quality work rather than on a low-bid basis.

Foster et al, 2012, reviewed the effect of distributors[84] of HVAC equipment on the uptake of incentives for energy efficient equipment in the USA. The review involved a combination of secondary and primary research. Sources used in the secondary research included energy efficiency program web sites, Public Utility Commission web sites, papers and information presented at efficiency industry conferences such as the ACEEE Summer Study and the CEE Industry Partner Meeting. Primary research included a web-based survey of HARDI member HVAC distributors and phone interviews with both HARDI members and energy efficiency program managers.

Specifically, they considered:

- The percentage of sales that could be attributed to high efficiency residential HVAC equipment.
- If distributors were offered training programmes.
- The percent of training on quality installation in accordance with the ANSI/ACCA 5 Quality Installation Specification.
- If the distributor had worked with the administrator(s) of their local energy efficiency program.
- If they are interested in playing a larger role in promoting high efficiency residential HVAC equipment.
- What distributors would prefer energy efficiency programmes to focus their incentive dollars on.
- The impact on distributors' business-as-usual practices.
- Distributors' influence on contractors.
- The percentage of efficiency programmes that offer contractor training, a preferred contractor list, or an upstream component

The study found that HVAC distributors play valuable, yet generally under recognised, roles, which can improve the outcomes of residential HVAC energy efficiency programmes. Specific areas ripe for partnership between efficiency programmes and distributors include programme promotion, stocking efficient equipment, contractor outreach, contractor training, understanding sales trends, and providing programme input. By recognising distributors as a crucial part of the manufacturer-wholesaler-contractor-consumer supply chain, efficiency programs can best

[84] Distributors sell equipment to installers; they may be independent or tied in some way to a particular manufacturer.

leverage those partnership opportunities and achieve their objective of increasing the sale and installation of efficient equipment.

Bickel et al, 2016, reviewed the effects of mid-stream (utility funded) incentive programmes for energy efficient HVAC equipment (specifically heat pumps, water heaters, circulators pumps boilers, A/C) to domestic customers in Connecticut, Massachusetts and Vermont. The research used sales data and surveys of distributors and customers involved in mid-stream programs. They found that when schemes changed from providing the incentive directly to the consumer (downstream) to providing it to the distributor (midstream):

- Sales of energy efficiency products increased (by between 50 and 100%, depending on the programme).
- Consumers were pleased – in particular in the reduction of paperwork that they had to complete[85].
- Installers were engaged via the distributors and in turn engaged their customers, increasing sales.

Gillich and Mohareb, 2018, analysed the Canadian Eco-ENERGY Retrofit Program (2009-2013) and US Better Buildings Neighborhood Program (BBNP, 2010-2013) using the programmes' own evaluation reports as well as supporting third party analyses. Both of these programmes were created with a national level overarching structure and objectives but were implemented in different ways at the state/provincial and local levels. Two of the study's findings relate to the supply chain:

- Programme organisers found that engagement with the participant workforce was essential. Many retrofit markets are at such an early stage of development that it is necessary to stimulate the supply push as well as the demand pull. Contractors would need to be persuaded to undertake new energy efficiency work in addition to their business as usual home renovation portfolios.
- Another local programme design factor that was critical to success was the degree to which the programme collaborated with pre-established community networks. These could include trade groups, credit unions, or community groups with no history of activity in housing. The success factor was creating the networks, often based on individual relationships, which enabled the programme to extend its reach in the community and calibrate its activities in the most suitable manner. A programme's local presence should include the local workforce and could not be entirely made up of external programme employees, as several grantees found that these were perceived as outsiders. Engaging the workforce as programme partners can help embed skills and practices in the local workforce that endure post programme.

Hawke, 2010, was commissioned by the Australian Government to review the Home Insulation Program (HIP). The review was instigated because 4 contractors died and over 100 house fires were linked to the installation of insulation. The HIP had twin objectives:

- To generate economic stimulus and support jobs and small business; and
- To improve the energy efficiency of homes.

[85] The authors noted that the paperwork for contractors was also reduced.

The programme was designed to provide easy access to work for lower skilled employees. At its peak (in November 2009), the programme had registered over 10,000 installers employing thousands of largely low-skilled workers. Although the review was undertaken because of the safety and fraud concerns that had arisen from the HIP, it did find that the programme also had positive elements. First of these is the insulation of over one million homes. Second was the adoption of innovative, cross-Government approaches. For instance, the delivery of the installer register and payment system through the established Medicare system supported high volume transactions and ensured rapid payment turnaround times (on average less than five days) These were critical to support small business cash flow. One of the reasons for engagement of Medicare Australia to deliver rebates was their established, national, operational systems for protecting against fraud. The Medicare system could also support electronic registration and payment and a call centre; and incorporated some upfront compliance checks. The third positive element was the accelerated development of training systems and maximisation of employment opportunities because the primary government department worked with the Department of Education, Employment and Workplace Relations (DEEWR).

Failings were identified in five key areas: programme governance (including roles and responsibilities), programme design and administration, risk management, audit mechanisms, and capacity issues. Concerns had been expressed by industry and state and territory authorities at the start of the programme. As a result of the programme there was a national focus on safety standards in the insulation industry and quality standards for materials and their installation. The installer register required minimum standards from installers and the guidelines required that insulation be installed appropriately. A national training program for ceiling insulation installers was in place and had provided training to over 3,700 people. Installers on the register were provided with safety information and warnings during the programme, including in the original training materials. Take up of the HIP was extraordinary and unexpected. Prior to the scheme 50,000 to 75,000 retrofit insulation installations took place per year. Early assumptions were that there would be around 90,000 installations per month under the scheme. In Phase 1 (3 February to 30 June 2009) there were around 70,000 claims for rebate. (During this phase authorised installers included owners or employees of registered businesses operating in the insulation installation industry).

More than 100,000 claims were received between 1 July 2009 (the launch of the full scheme) and 12 August 2009. By November 2009, the number of claims had peaked at nearly 180,000 per month. This high demand put pressure on the systems and staff who were administering them. At the time the programme closed on 19 February 2010, over one million homes had been insulated.

At its peak, in November 2009, there were over 10,000 registered installers (of these approximately 7,000 were active installers and had made at least one claim). The number of registrations had dropped to around 2,500 by 19 February 2010, following a requirement for registration under more stringent qualification criteria.

Hawke's findings were that:

- Trade-offs are unavoidable (here between providing easy access to new players - businesses and job seekers in the industry - and adequate entry requirements / training to address safety and quality issues) so they must be carefully balanced in programme objectives and design as well as implementation.
- Some installers pushed hard to generate business and there is anecdotal evidence of door knocking and aggressive cold calling.

- The programme design considered the need to deal with safety and fraud issues and there was an assumption that the approach of “one strike and you’re out” would apply to installers shown to have a poor safety record or when there was evidence of potential fraud. As the number of claims and registered installers rose to unanticipated levels and the compliance and audit programme rolled out, the number of complaints and safety concerns mounted. Effective use of the one strike policy came too late.
- There is now a much lower number of people and businesses capable of providing assurances that they can operate safely and with integrity in the insulation industry. Given the size of the inspection and rectification programme that the Government has embarked on, many of the reputable players will be required to implement inspection and rectification measures.

Reviews of consumer interaction with supply chains

Murto et al, 2019, used two qualitative approaches to explore how and to what extent the marketplace provides comprehensive whole house retrofit projects for landlords (housing companies) in Finland:

- Through ethnographic participant observation of housing companies initiating an energy retrofit acquisition process, which formed an extended five-month version of being a ‘*mystery shopper*’.
- Interviews with 12 housing companies that have gone through the full energy retrofit process. The sample includes housing companies that have installed a ground source heat pump system or a hybrid system which has other energy efficiency and/or energy technologies in addition to a ground source heat pump. NB these housing companies typically possessed the strong technical competences or experience to manage this type of project.

Their findings from the “*mystery shopper*” were:

- This is a complex process and lots of time is required to gather the information needed to make the right choice.
- Specifying the right information about the site was difficult; to some extent because it was not easy to access in itself (the property manager had to supply it) and also because it was being collected by someone who was not an expert and therefore did not present it correctly.
- Establishing sufficient information for comprehensive refits was difficult under uncertainties and self-interested biases (i.e. sales literature not being totally accurate).

More generally:

- Eight out of the 12 completed projects had involved use of an energy consultancy company, despite the housing company management or Board having some technical competence. These consultancies were identified through personal networks, through the housing company’s property management service company, or simply by chance. The consultants were key in mediating between the housing company and the suppliers, especially by comparing offers, coordinating the overall system integration and managing the installation. A cross-examination of the participant observation and interview data led the authors to conclude that it is not easy to find energy consultants. When searching for the energy consultants named in the interviews using 41 saved

internet searches made during participant observation (each containing 100 search items), only three matches surfaced, two of which no longer offered the service. Additionally, a search of the consultants from a certified installer portal put together by an energy consultancy body yielded zero matches.

- From the housing company perspective, a satisfactory solution requires the integration and combined assessment of energy efficiency and energy generation technologies. The markets did not match this demand: they are dominated by suppliers of narrow solutions and lack actors who adequately mediate between available solutions and users. This holds true even for relatively simple solutions but is much more of an issue for attempts to commission comprehensive energy retrofits.

de Wilde, 2019, undertook 40 in depth interviews with homeowners who adopted a domestic low-carbon retrofit measure, aiming to establish how trust impacts on the retrofit market. The respondents targeted were owner-occupiers throughout various cities and villages in the Netherlands who had purchased a low-carbon retrofit measure, such as insulation (floor, roof and cavity) or PV panels, within six months of the study. The sampling led to an interview sample containing owner-occupiers who were predominantly: male, above 55 years of age and highly educated. The author found that homeowners struggled with contractors in three respects:

- Trusting their advice given that they had a vested interest – i.e. they were selling a particular system or product.
- The poor transparency of quotes – they were difficult to understand and to compare.
- When the work was completed they lacked confirmation that installation was good quality - that it has 'worked'

Systematic review

Kivimaa and Martiskainen, 2018, undertook a systematic review case studies of retrofit projects involving elements of innovation. They specified a 10-year publication date range of 2005–2015 and limited the review to peer-reviewed academic journal articles. A case here was defined as an empirical study describing a process of low energy building innovation/process, involving measures such as residential housing refurbishments and zero carbon new build homes (built on site or pre-fabricated) as well as novel business models or programmes for low energy buildings.

Their research questions were:

- What drivers have been important for systemic and architectural innovation in low energy buildings in Europe?
- What actors act as intermediaries and through what processes do they intermediate systemic and architectural innovation in low energy buildings?

The second question could have aligned well with this REA, however the intermediary actors considered in the review are largely outside a narrow definition of the supply chain and therefore their findings are not considered directly relevant:

"*Intermediary actors represented 23–25 different organisations, 13–15 operating locally and nine nationally and one globally. Ten types were represented: local authority agents (e.g. local councils, planners, an energy manager, a Local Agenda 21 co-ordinator), municipal housing*

funds/corporations, private housing funds/corporations, business network organisations (trade bodies), independent groups/foundations, government energy agencies, a government innovation agency, consultants, a regional energy utility and an international competition. Public organisations seem to dominate as 19 cases involve public sector intermediaries, while only nine describe private sector intermediaries (in 12 cases, no intermediary-type actors were described)."

This piece of evidence is included to demonstrate that a recent, closely related review, using similar search terms, found little evidence – of the 40 case studies identified only 9 related to renovation. To quote from the paper "*Although in practice multiple demonstration projects and pilots around low energy new builds and retrofits have been carried out all over Europe, the review finds that very few have been subjected to academic scrutiny and in-depth qualitative analysis from an innovation studies angle. This is besides the wealth of research on the technical qualities, economics, architectural design, domestication, attitudes towards and the policy and politics of low energy buildings. What is also surprising is that, what can be classified as qualitative case studies of low energy building innovations or projects promoting them, were found to concentrate only in five EU member states: Belgium, Denmark, Finland, Slovenia and the UK. A broader use of search words pertaining to technology revealed case studies also in France, Germany, Sweden, Spain and the Netherlands, while the predominant focus of the case study literature was in Denmark and the UK*."

REAQ1 evidence synthesis: secondary questions

Does upskilling have an impact on the uptake of energy efficiency retrofit?

One source provided some evidence:

Gillich and Mohareb, 2018, in their review of the Canadian Eco-ENERGY Retrofit Program (2009-2013) and US Better Buildings Neighborhood Program (BBNP 2010-2013), found that "*Contractors would need to be persuaded to undertake new energy efficiency work in addition to their business as usual home renovation portfolios. If this required new skills, new staff, or new equipment, the program had to respond to these needs to ensure that a suitably qualified workforce was available to meet demand. The circumstances varied enormously by location and the best practice principle at the national level was to give local programs the flexibility to spend program funds as they saw fit, even if that was on directly paying for training the workforce. The use of public funds for developing skills in private trades is controversial. Some feel that this is an area best addressed by market forces, with a baseline performance maintained through building codes and standards. While this might hold true for well developed markets given sufficient time, if program designers want to deliver a high volume of quality retrofit projects and increase the perceived value of retrofit within program timescales, then investing in skills development is all but essential.*"

How skilled is the retrofit supply chain?

The evidence suggests a lack of adequate skills in the supply chain:

- **Gillich and Mohareb, 2018**, imply that the skills for retrofit were not widely available as some programmes had to set up training programmes. **Thorne, 2003,** implied the same situation in her earlier review of US programmes.

- Likewise, **Murto et al, 2019**, reported that Finnish housing companies had found that the retrofit market was dominated by suppliers of narrow solutions rather than comprehensive packages, and lacked actors who adequately mediate between available solutions and users.
- **Hawke, 2010**, identified that there were relatively few workers skilled in roof insulation in Australia; despite available training there were insufficient numbers to respond to the huge surge in demand from the Home Insulation Program.

No evidence was found for the other secondary question: "*What is the cost of retrofit, how does this compare with the cost of general home improvements, and how has this influenced uptake?"*

REAQ2 evidence synthesis: primary question

"*What is the evidence of how supply chains for domestic energy efficiency retrofit operate outside the UK?*"

Evidence base characteristics

There were 15 academic pieces of evidence relevant to this topic, and 16 from the grey literature, making 31 in total. The majority dated from 2010 onwards, with one outlier from 2000.

The split of sources by country description is shown in Table 4 below (NB several studies described more than one country so the total is more than 31).

Table 4: Evidence synthesised by country for REAQ2

Country	No of grey sources	No of white sources	Country	No of grey sources	No of white sources
Australia	1	0	Italy	1	0
Austria	1	1	Latvia	1	0
Belgium	5	1	Lithuania	1	0
Canada	2	0	Netherlands	4	2
Denmark	6	1	Norway	2	2
Estonia	2	0	Slovenia	1	0
Finland	1	1	Spain	2	0
France	7	1	Sweden	0	2
Germany	5	1	Switzerland	1	0
Ireland	1	0	USA	1	1

The next section gives an overview of energy efficiency retrofit supply chains, as reported in the literature. This is followed by country by country supply chain descriptions. Finally, more detail is presented on the innovative 'One Stop Shop' approaches being developed to provide more comprehensive and co-ordinated offerings to the consumer.

Overview of building supply chain for energy efficient retrofit

Researchers have reported that the supply chain for domestic retrofit is fragmented in the EU[86] and, by country, for instance in the Netherlands[87], Denmark, Finland, Norway and Sweden[88], France[89], the USA[90] and Australia[91]. Fragmentation leads to poor quality retrofits[92]. In addition, retrofits are not generally a high priority for traditional building contractors e.g. in Sweden[93], Belgium[94], and France[95].

The supply chain is dominated by SMEs. One study found that in these businesses, the competencies and resources to develop an innovative, partnership-based, business model for scalability were limited[96]. The reason for this is not given. This is important because researchers found that successful retrofit offers depend on integration at the interfaces between the traditionally separate and fragmented roles played by contractors[97], and between innovations among the three Ps – products, practices and processes[98]. Nonetheless, small builders can be innovative if clients allow time and money for experimentation[99].

There are actors who can act as intermediaries. Researchers found in a systematic review of low energy building innovation case studies[100], that a variety of types of organisation take this role: local authority agents (e.g. local councils, planners, an energy manager); municipal housing funds/corporations; private housing funds/corporations; business network organisations (trade bodies); independent groups/foundations; government energy agencies; a government innovation agency; consultants; a regional energy utility, and an international competition. Public organisations seem to dominate.

Details of energy efficiency retrofit supply chains in individual countries

Belgium

The involvement of specific consultants is always necessary for retrofit projects for single family houses, because every major renovation has to be filed by an architect, and every energy performance certificate has to be filed by an accredited trained energy expert. There is a legal obligation to have the roles of an architect, safety coordinator, energy reporter and ventilation reporter. Depending on the size of the works, the same stakeholder may undertake

[86] Boza-Kiss and Bertoldi, 2018
[87] De Wilde and Spaargen, 2019; Brown et al, 2018
[88] Mahapatra et al, 2013
[89] Killip et al, 2014
[90] Brown et al, 2019
[91] Hawke, 2010
[92] Brown et al, 2019; Killip et al, 2014
[93] Pardalis et al, 2019
[94] Cré et al, 2012
[95] Nösperger et al, 2011
[96] Mlecnik et al, 2017
[97] For evidence on this from the Netherlands and the US, see for example, Brown et al, 2018; Brown et al, 2019
[98] Killip et al, 2014
[99] Mlecnik et al, 2019
[100] Kivimaa and Martiskainen, 2018.

more than one role[101]. In the development of consortia, it was difficult in particular to agree revenue allocation between specific consultants and the contractors and installers[102].

A large percentage of the renovation sector supply chain consists of micro companies. These companies prefer to cooperate with other companies, with strong preference for collaboration with architects or engineers[103]. Energy efficiency projects are a small proportion of their work. Most respondents to a survey reported in the literature (80%) noted that consumer awareness is vital to the success or failure of facilitating holistic energy-efficient renovation projects. The customers have to know that the possibility exists and have to be aware of the added value. In this context, most companies also indicate the need for grants. 51% of respondents indicated that a focus on improving awareness about energy efficiency renovation amongst companies was also important. Workshops and seminars are seen as the best way to facilitate the exchange of knowledge. A website is seen as an opportunity to share knowledge[104].

Denmark

Reuss and Allingham, 2011, reviewed the background and strategy for saving energy in homes and buildings in Denmark. They found that there are specific requirements in the building regulations concerning energy performance for different classes of renovation. Also, training is required before tradespeople in Denmark act as energy advisers. The training was a three-day course catering for many types of tradesmen, including installers, who then received a certificate that allowed them to advise homeowners on energy efficiency. Energy advisers were able to determine the energy saving potential in all types of buildings.

Vito, 2016, found that the tax administration was heavily involved in refurbishments in Denmark (there was a tax reduction for refurbishment projects) and that the energy supply company has a role in payments of the subsidies. However BPIE, 2017 found that the available financial subsidy scheme for energy renovations in Denmark is modest and rarely decisive for the building owners' decision to invest.

One Danish case study[105] showed that an intermediary actor (in this case a bank) could promote energy efficient behaviour in various ways, by disseminating knowledge, creating connections, or providing the capital for works to reduce energy consumption.

In another case, in Frederikshavn's municipality[106], homeowners were offered energy consultancy and preparation of energy saving report free of charge. Energy consultants directed homeowners to their banks. Bank advisors were trained to understand the contents of the home energy report, and based offers of soft loans to the homeowner on this.

France

Nösperger et al., 2011, found that there were about 318,000 companies in the building construction sector in France. Almost all of which (97 %) were "craft" companies with less than 20 employees. These companies could be split into two broad categories: (1) general builders carrying out structural works, and (2) specialist contractors. Very small-sized companies (with an average staff of less than 5 employees) operated principally in the residential market. In turn, about 57% of the small building companies worked mainly on the home renovation market, most of the time on their own. They generally had a high influence over specification of

[101] Vito, 2016
[102] Mlecnik et al, 2019
[103] Cré et al, 2012
[104] Ibid.
[105] Maneschi, 2013
[106] Vesta Conseil et Finance, 2018

works. They worked with 4 or 5 suppliers e.g. mass-market distributors, specialised material traders, etc.

Installers acknowledged that they lack training and 75% stated that they sought technical information from equipment or energy suppliers, whereas 61% paid for training for their staff and 38% asked for support from public or professional organisations.

Nösperger et al., 2011, found that heat pump market development in France illustrated the impact of a new technology on the established system of professions. The jurisdiction of home heating and cooling used to be divided among electricians (dealing with electric convectors), plumbers (boiler fitting) and air-conditioning professionals. However, proper sizing of heat pumps requires a more accurate prediction of heating and cooling loads than is the case for a standard boiler. Therefore, fitting a heat pump requires joint competencies in electricity, centralised water-based heating systems (e.g. boilers), and thermodynamic properties of the house and its use. None of these trades used to have all these competencies. From a technical point of view, A/C specialists would be the most suitable trade but they usually prefer to deal with large installations. As a consequence, the residential heat pump fitting market was imperfectly split between these three trades.

From a survey in 2009, these tradespeople seemed to have perceived this change as an incremental one and had not really considered the global energy performance of the building in their approach. Only a few (10-15%) intended to set up or join a formal “skill-network” for cooperation/ subcontracting in order to help renovate the housing stock. The low overall percentage of respondents indicating that they would adopt these strategies for acquiring new skills indicates that the scale of the building stock refurbishment challenge was not appreciated by survey respondents. However, a significant share of plumbers (21%) intended to integrate building insulation in their offer.

Their lack of involvement in delivering an adequately performing building was also reflected by their disappointing commitment to maintenance. Although most boiler fitters offer a maintenance service, only 50%-60% of the other tradesmen do so, yet the energy performance of the building requires ongoing maintenance. That means that only roughly 60% of the existing tradespeople were likely to deal with the building performance challenge, even if they focus only on their speciality (ibid.).

35% of installers themselves acknowledged poor competence in the new technologies and 46% said that vigorous demand for existing services prevent them from changing their professional offerings. Moreover, the demand for highly energy-efficient solutions still seemed too small for them to change. 25% of those surveyed said they had not been asked to provide energy efficiency services, and 11% did not think the market for these services would grow (ibid.).

Another study reviewed six French projects[107]: three individual detached houses and three collective housing buildings. They found that in many cases architects played a key role in orienting homeowners towards comprehensive energy-efficient retrofits and that project architects in France usually have advisory skills in terms of energy efficiency. Most of them work in collaboration with a specialised advisory firm.

In these cases, several skills were grouped within integrated project management companies; these included at least one architect and one energy efficiency expert, and sometimes an economist. This organisation enabled managers to offer clients several refurbishment

[107] Beillan et al, 2011

scenarios which, according to the interviewed homeowners, facilitated the decision-making process. The scenarios allowed decision-makers to compare several refurbishment projects based on costs, energy performance and financial support available in each of the cases. Many owners paid a lot of attention to the recruitment of qualified companies, capable of implementing the required technical solutions and collaborating with other involved professionals. This was because energy-efficient retrofit projects were considered to require special qualifications that only a few professionals possess. Hence owners sought companies that met these requirements or got closely involved in the worksite themselves to assure project success.

Germany

A number of authors have reviewed the programmes for improving the energy efficiency of buildings that the public bank KfW (Kreditanstalt für Wiederaufbau) had been commissioned by the German government to lead since 1996.

The programme offers low interest loans to householders[108]. “Energy consultants” are involved in defining the refurbishment measures; these are energy specialists in building technologies, registered on two lists which are available to the general public and administered by DENA (the German Energy Agency) and BAFA (Federal Office of Economics and Export Control)[109]. These are well used, providing a wide range of advice depending on the target group: home energy checks, consultation on energy-related refurbishment, initial consultation at local information centres, initial on-site consultation, on-site orientation and counselling service, and concept-oriented consulting engagement[110]. DENA, has initiated a partnership (Allianz für Gebaüde-Energieeffizienz) involving professional organisations, energy suppliers, renovation solution suppliers and research institutes[111]. This aspect of the German approach does not seem to have any equivalent in the other countries studied in one report (France, Italy, Spain and Switzerland)[112]. Yet, even so, skilled, qualified energy-efficient retrofit professionals in every building profession (engineers, architects and contractors) are still few and far between, even in more advanced countries like Germany.

Despite acknowledged overall success, the programme has nevertheless not been sufficient to meet the high ambition of a 2% energy renovation rate per year (the overall result has been close to 1% per year). The apparent simplicity of the scheme, which is an important factor in aiding consumer take up, has likely been a key success factor (together with the attractiveness of the incentives)[113].

Netherlands

In the Netherlands the local authority takes an active role in launching awareness campaigns and information programmes[114]. Also, banks provide independent financial advice on possibilities for financing and subsidies and energy consultancy services are used in the Netherlands for energy advice. Many thousands of homes have been retrofitted under the Energiesprong initiative[115].

[108] Vesta Conseil et Finance, 2018
[109] Beillan et al, 2011
[110] Vito, 2016
[111] Broc et al, 2015
[112] Beillan et al, 2011
[113] Broc et al, 2015
[114] Vito, 2016
[115] This is covered in detail in the later section on ways of collaborating

Norway

Mlecnik et al., 2019, found that all Norwegian consortium models are dominated by contractors because Norwegian consultants are not as involved in retrofit projects, in contrast to other countries in the same study (Austria, Belgium, Netherlands and Germany).

Spain

Beillan et al., 2011, found that for most Spanish cases, architects played a key role for orienting homeowners towards comprehensive energy-efficient retrofit. The architects involved were particularly receptive to the energy topic, unusually for their profession in Spain, and many had advisory skills and integrated energy efficiency into their projects. However, architects do not seem to draw upon the skills of consultancy firms. Spanish professionals had not yet achieved competences to assess buildings' energy performance. In most cases, Spanish landlords had not considered this issue, leaving all decisions to architects as the trusted experts. In one Spanish case study, an insulation manufacturer explained the benefits of insulation to co-owners. That type of intervention is important in Spain, where homeowners pay little attention to energy issues.

Sweden

Pardalis et al., 2019, undertook interviews with owners of 21 Swedish SMEs, of which 19 were micro and small (MSE) construction enterprises. They found that the majority of the interviewees showed a keen interest in a One Stop Shop model. They claimed that it would open space for collaborations with professionals from other fields of business, which could provide a great opportunity to strengthen their position in the market, expand their market and networks and increase their profits.

However, this market was not their present priority. Reasons given for this were that they were busy working in new construction and have limited time and human resources to deploy in renovation projects. Some of the respondents argued that if there was a more favourable tax environment for small companies, they could recruit more staff, so they can take advantage of the business opportunities that the house renovation sector offers. However, a small number (5) of the respondents argued that they know of state funding opportunities for the development of small businesses and the development of new sustainability-related products and services. According to them, however, both they and most businesses in their sector do not know how to access these funds. They claimed that their firms do not have capability to deal with complex business structures. They were worried that the adoption of such a model would cause a great disturbance to the balance they have managed to achieve in their business, and disappoint their employees, whose satisfaction is considered the key for companies' success. They insisted that investing in changing their business model is valued less than investing in creating opportunities for an improved working environment. Concerns were raised regarding the complexity of the model with most of them referring to risks related to the adoption of an innovation, such as creating a negative decision environment for them and for training their staff. The lack of project management competence among most of the MSEs owners makes them concerned for whether they would be able to deliver efficiently what would be promised to the customer. The vast majority of MSEs owners claimed that their work is *'… rather specialized and unique in each project…*', and that they were unable to '*… fit in someone else's working schedule, when having ongoing projects …".*

Other European countries

Vito, 2016, reviewed the situation for multi-apartment buildings in Estonia and Slovenia. In Estonia the energy agency is responsible for launching awareness campaigns and for

providing all general information regarding energy efficiency. While the local authority issues the building permit and supervises the legal aspects of the construction, the building inspector is in charge of supervising the technical aspects of the construction process. He is hired by the owners of the building and it is a compulsory role in Estonia. The KredEx Fund provides consultation, subsidy and expertise if needed. The energy consultants provide advice on HVAC and technical aspects of the renovation. In Estonia, there is no obligation to hire a building manager but, where there is a manager involved, he can represent the home owners in the negotiations. On the other hand, a technical consultant must be hired to be eligible for the renovation fund. He supervises the project design and coordinates the tendering amongst other responsibilities.

The study found that in Slovenia the building manager takes the initiative to propose renovation to the owners, negotiates on behalf of the owners and launches the public procurement process. There is also a local authority-created organisation, “ENSVET”, a municipal office for the transfer of knowledge.

USA

Most retrofit programmes in the US are operated at the state level by utilities and funded by ratepayer subsidies rather than public funds. However Gillich et al., 2018, reviewed the US Better Buildings Neighborhood Program (BBNP), which was a federally funded programme, consisting of 41 different versions of thermal retrofit programmes with a common structure and objectives. The programme was created in the wake of the 2008 recession as part of a US$840 billion stimulus package. Under BBNP, The Department of Energy competitively allocated US$508 million to 41 state and local programmes. It therefore differed from previously typical retrofit activity in the US in two key ways: (1) states must meet the federal funding criteria and common programme objectives; and (2) it was a temporary stimulus with a fixed spending period (September 2010–August 2013). This created a natural experiment in thermal retrofit programme design.

Gillich et al., 2018, found that 14 programme steps were common to all BBNP grantees and five themes emerge from best-practice principles associated with each programme step: (1) programme design: local market features and suitable programme structures; (2) marketing and outreach: the processes of creating awareness versus personal engagement – how community-based social marketing is a key strategy in driving demand; (3) workforce engagement: the skills gaps across the supply chain; (4) financial incentives: the merits of grants versus loans – how to use them in combination; and (5) data and evaluation: best-practice techniques for both programme evaluation and enabling iterative programme adjustments.

A later paper[116] identifies a so-called SMIT plan, which has emerged from examining different regional approaches to energy efficiency products (heat pumps, cooling, etc). Its objective is to engage the supply chain, using incentives to increase uptake of more efficient products and measuring success in terms of change in sales. This plan encompasses:

- Sales. The data can inform incremental measure costs, provide information about the levels of energy efficiency, and the necessary level of expertise to sell the product.
- Marketing. Everything from warranty information to pitching the type of replacement (planned or emergency) can be shared through a strong marketing effort. Furthermore, if an efficiency programme has historical and forecasted product sales from market

[116] Merson et al, 2018

actors, with seasonal factors considered, this can be incorporated. Other useful data involve established sales and marketing strategies and collaborations with manufacturers, their representatives, and distributors.

- Inventory. Adequate inventory information (stocking percentages, for example) helps programmes inform the supply channel about elevating inventory levels, given any new or redesign utility programme protocols' forecasts of demand. This is especially the case if the programme can inform supply channel plans for adding products to buyers' lists, and for calculating lead times for adding inventory. For example, heat pump manufacturing requires long lead times, because the sources (and the myriad elements for bringing them to market) are predominantly located in Pacific Rim countries.

- Training. The programme can offer proactive product and programme training, information on utilities, delivery (seasonal, project related), and other data necessary for laying the groundwork for achieving speed and scale on market transformation. Knowing a supply chain company's training practices and other protocols can help the program offer streamlined value to the company.

Australia

The Home Insulation Program (HIP) was launched in direct response to the global financial crisis and was unprecedented in its scale and speed of implementation. Hawke, 2010, reviewed this for the Australian Government. The programme ran in 2009 and 2010 and was originally designed to generate economic stimulus and to provide insulation to 2.7 million homes that were inadequately insulated. Both at state and territory level, it was designed to be implemented as fast as possible, with a reduction in red tape. The insulation industry was a disparate one (in terms of insulation products, business models and industry organisation) and largely self-regulated. Programme delivery mechanisms, which required innovative approaches, were developed and rolled out in very short timeframes. For the first time there was a national focus on safety standards in the industry and quality standards for materials and their installation. HIP registered over 10,000 installers at its peak.

The Government did not contemplate any changes to industry settings for the programme. State and territory regulatory frameworks varied and there was no established pathway for national HIP delivery. A high reliance was placed on state and territory regulatory authorities to carry out their occupational health and safety (OH&S), product compliance and complaints handling responsibilities effectively,.

Working in ceiling spaces is inherently risky. Safety and fire concerns regarding insulation pre-date the HIP. Industry told of earlier attempts to develop training packages with the states. Of the 1000 targeted inspections of foil insulation in Queensland, around 20 per cent were found to have pre-existing electrical safety issues. Although firm data is difficult to come by, over 80 fires per year were associated with insulation before the start of the programme. These numbers are in the context of 50,000 to 75,000 retrofit insulation installations per year.

The HIP took the government into construction industry operations where it had little expertise. Programme delivery mechanisms, which required innovative approaches, were developed and rolled out in very short timeframes.

The commissioned risk report indicated that the programme (given its scale and complexity) raised significant capacity issues for the government department responsible[117]. These were in part addressed through the design of the business model, external contracting and partnership

[117] The Department of Environment, Water, Heritage and the Arts

arrangements (e.g. with PwC as audit and compliance service provider and Medicare as the delivery agency) and internal restructuring in the department. This is an appropriate approach, but this review suggests that it was not backed up by the necessary level of dedicated internal senior executive oversight or sufficiently timely contracting out.

Overall, the speed and quality of implementation led to poor quality workmanship and materials, some unsafe work practices, a high level of fraud, a number of fires, and, most critically, four deaths (of installers). This led to an abrupt halt to the programme; however it did result in over one million homes being insulated. The review states that tradeoffs were unavoidable (between providing easy access to new businesses and job seekers in the industry and adequate entry requirements and training to address safety/quality issues) so they must be carefully balanced in programme objectives and design as well as implementation. No information has been found about any later problems as a result of the programme.

Canada

Parekh et al, 2000, reviewed the EnerGuide for Houses Program (EGH). Energy Evaluators played a key role in the programme, determining the EnerGuide Rating (on a scale of zero to 100) for each house.

Another Canadian study[118]identified three major problems impeding the ability of the Canadian construction industry to implement low carbon construction in the workplace:

- The extensive and largely unregulated underground economy.
- Fundamental weaknesses in the training and apprenticeship system.
- The failure to include workers - and the unions that represent them - in the process of greening the built environment.

These findings arise from:

- 29% use of underground (i.e. tax avoiding) work, which creates a barrier to skill development.
- The low number of apprenticeships, high dropout rate (> 50%) and regional patchwork quilt of approaches.
- Low levels of union membership.

The study concludes that. whilst these are not the only problems, addressing them is essential.

Evidence theme: Ways of collaborating across disciplines and roles to provide integrated renovation services (‘One Stop Shops’, ‘Rescos’, or ‘Consortia’)

A number of new ways of collaborating, to address the need for integration and appropriate ways of presenting information for choice, have been identified and reviewed. Many of these also include feedback mechanisms to allow the monitoring from one project to inform the development of the next, and for this to be coordinated in a systematic way to help accelerate the diffusion of new practices across the industry more generally[119].

[118] Calvert, 2014
[119] Janda and Killip, 2013

There are important differences between ways of integrating activities for individually owned homes and for multiple home properties. Häkkinen et al., 2019, identify the need for a new type of role to accelerate district-level energy efficient refurbishment projects, defined as an "activator". This encompasses:

1. Project consultant
2. Project Developer
3. Project Integrator

Each of which undertakes aspects of 5 activities:

1. Assesses potentials
2. Motivates
3. Collects a group of building owners to start neighbourhood scale refurbishment
4. Provides services
5. Coordinates and networks

Mlecnik et al.', 2017, assessed experiences from 24 active consortia for single family home retrofits, across Austria, Belgium, Germany, the Netherlands and Norway. Their findings stress that the market is still largely dominated by SME's with limited competencies and resources for networking and collaborative business development.

Two models have been seen to be effective to overcome these issues. The first is the multi-skilled team based on shared tasks, shared risks, and shared problem-solving. The second is the involvement of an effective 'integrator' to manage on-site teams and provide an important link between the physical work being carried out, the technical demands of the energy targets in the design, and the interaction with the client[120]. What is most important is that the integrator has good project management skills.

The possible range of actors found in some form of intermediary role is very wide, and the nature of the role is also varied, depending on the nature of the project and the other actors involved. It is suggested that an independent person is better suited to this role. An experienced project manager can operate effectively on low-carbon projects without being an energy expert (so long as more expert advice is available within the retrofit team or scheme). However, the reverse is not generally true: an energy expert with deep technical understanding but shallow project management skills cannot operate successfully on these projects. When interviewees were questioned further about the essential characteristics of a low-carbon refurbishment project manager the answer from was: 'it's about managing the interfaces'.

The two models are not mutually exclusive and the need for flexibility in the various contexts for retrofit may mean that some combination of both approaches will be necessary, depending on the circumstances of each project.

A number of examples of collaboration across disciplines and roles to provide integrated renovation services have been identified, called by various names ('One Stop Shops' (OSSs) or 'Rescos', or 'Consortia') or referred to as new business models for integrated renovation services. The OSS finds a niche market to act on because there is fragmentation both on the

[120] Killip et al, 2013

supply side and on the demand side[121]. On one hand, the clients that would like to engage with a building renovation project find that it requires information, expertise and a complex project management. The client would have to deal with a large number of providers and suppliers, be aware of a large number of legal and regulatory requirements, administer a large number of certifications, and maybe even apply for grants, loans or other forms of financing. Besides being time-consuming, it is close to impossible for a regular citizen to establish informed choices about the combination of possible solutions, timings and organisation. An OSS can take this decision process over from the client.

At the same time, the renovation actors (planners, engineers, installers, manufacturers, financial partners, etc.) also find it difficult to engage with single private clients, who need a lot of time-investment in cumbersome information-provision, visits, failed decisions, and the clients seem to be very varied from a supplier's point of view. They can also benefit the pooling capacity of an OSS[122].

One Stop Shops have been categorised[123] based on their structures:

- Local-government supported or initiated OSSs.
- Independent consultant-based OSSs.
- Industry-driven OSSs: Funds or financial credit lines with a primary aim to support the financing of the energy efficiency market while they boost their services with technical assistance and/or tools.

In another study across Austria, Belgium, Netherlands, Norway and Germany[124], most of the business models found were initiated by private renovation professionals (mostly consultants, e.g. architects, energy advisors and/or contractors) who took the lead in forming a consortium. In some cases, a public intermediary (e.g. a local authority and/or a non-profit organisation) took the initiative and developed the business model. The different contributing consortium members took on specific roles in the homeowner's customer journey, from informing and consulting to contracting, executing and assuring quality. The study found also that the innovation risks related to introducing sustainability approaches and the fear of high transaction costs associated with building up new knowledge were hindering engagement of SMEs.

The One Stop Shop type initiatives found in the literature are listed in Table 5 below, together with the countries in which they operate and, where available, the number of dwellings where measures have been implemented. The list includes only initiatives that have been implemented: proposed projects or approaches that have been discussed in theory only are excluded.

[121] Boza-Kiss and Bertoldi, 2018
[122] Ibid.
[123] Ibid.
[124] Mlecnik et al, 2019

Table 5: One Stop Shop Initiatives identified

Initiative name	Country	Number of dwellings acted upon	Source(s)
Izigloo (now Mon carnet)	France		BPIE (2017)
Operene	France	4,000	BPIE (2017)
Energiesprong (now Stroomversnelling in the Netherlands)	Netherlands	3,886 BPIE (2017) 1,300 Ne Boza-Kiss and Bertoldi (2018) 4,500 Brown et al. (2019)	BPIE (2017), Brown et al. (2019), Boza-Kiss and Bertoldi (2018)
BetterHome	Denmark	1,182	BPIE (2017), Boza-Kiss and Bertoldi (2018)
Oktave	France	9,180	BPIE (2017) Boza-Kiss and Bertoldi (2018)
Energy Savers Program	Chicago US	7,500	Boza-Kiss and Bertoldi (2018)
Superhomes	Eire	200	BPIE (2017)
RenoWatt	Belgium	136	Boza-Kiss and Bertoldi (2018)
SHELTER projects	France	245	Rahola et al. (2014)
SiRE	Spain	74	BPIE (2017)
REFURB	Denmark, Belgium, Netherlands, Estonia, Slovenia, Germany		Vito (2016), Boza-Kiss and Bertoldi (2018), Vesta Conseil et Finance (2018)
ProEnergy	Eire		BPIE (2017)
Kredex	Estonia		Boza-Kiss and Bertoldi (2018)
Service Public de l'Efficacité Energétique (SPEE)	Picardie (France)		Boza-Kiss and Bertoldi (2018), Vesta Conseil et Finance (2018)

Initiative name	Country	Number of dwellings acted upon	Source(s)
CLEAR	Belgium, Italy, Spain, Portugal, Netherlands	26 group purchases completed	Boza-Kiss and Bertoldi (2018)
Reimarkt	Netherlands	1,750	Boza-Kiss and Bertoldi (2018), Vesta Conseil et Finance (2018)

General findings about these types of operation

A number of resources reviewed OSS in several countries:

- A comparative review of 14 One Stop Shops in 8 countries[125], which analysed the different structures they can operate under.
- A review of 24 consortia in Austria (5), Belgium (5), Netherlands (5), Norway (5) and Germany (4), formed as part of the COHERENO project[126].
- A set of 10 case studies[127], which covers some of the same ground from the Netherlands, Belgium, Latvia, Germany, Estonia, France (2), Denmark (2).
- A study which considered the supply side involvement in innovative projects in Belgium, Netherlands, Denmark, Estonia, Germany, Slovenia, funded by the H2020 REFURB project[128].
- A review of eight detailed reports prepared for the three year (2009–2012) Nordic project ‘‘Success- Families’’ (Successful Sustainable Renovation Business for Single-Family Houses)[129].

Volt et al., 2019, considered that the overriding principle of an OSS style approach is that the integrated service should aggregate services from various actors and define clear roles for each of them, including both their commitment to a set of responsibilities and the benefits accruing to them; however Mlecnik et al., 2017, noted that many SME’s have:

- Limited competencies and resources for networking; and
- Lack of knowledge of basic ideas of business models, particularly when it comes to defining the customer interface.

Perceived barriers to collaborative business model development are the ability to communicate and convince larger groups of homeowners, insufficient time and budget to develop the consortium and agree the business model across the conflicting interests of the collaborators,

[125] Boza-Kiss and Bertoldi, 2018
[126] Mlecnik et al, 2017
[127] Vesta Conseil et Finance, 2018
[128] Vito, 2016
[129] Mahapatra et al, 2013

lack of interest from policy makers, and lack of information about homeowners' needs[130]. Mlecnik et al., 2017, considered that an integrated perspective has to be embedded, checking ideas from the market perspective, developing procedures to raise customer awareness and gain customer confidence, and making use of the individual businesses' own reputation, networks and customer channels. Ideally the business model development process results in a strong joint commitment or involvement of other necessary key partners (to be able to reach a larger group of homeowners). A strong network in the market in which they are each active is a success factor here, as local installers often have good long-term relationships with residents[131]. It remains a challenge to determine a fair risk distribution between partners and to integrate independent advice in one-stop-shops and it takes time to build trust between these actors and to find the right cost structure[132].

After this business model development, it is crucial to start as soon as possible with a first demonstration project for the consortium and that this may generate additional unforeseen barriers. It is noted that smaller consortia, as well as actors that already knew each other, came to a common understanding more easily[133].

Vito, 2016 found that the energy auditor/expert is probably the most important player in the value chain, as they are the interlocutor who provides advice and can sell the idea of an energy renovation. Generally, most people interested in a renovation initially only want to implement one to two measures (e.g. heating system replacement, new windows etc.) but tailored advice can inspire additional work. Financial institutions and local authorities can empower the OSS with a unique selling point, which can include perks like a lower interest rate for clients or a streamlined administrative process. The study also found that the most important aspects for successful delivery of the integrated offer are service provision and customer management. Services include renovation advice, building check/diagnosis, developing a renovation package, implementation of the actual measures, post-installation check etc. The other activities aim to keep the customer satisfied. Aspects such as a good customer relationship, which can be the unique selling point, can include a single-point of contact (including for invoicing) throughout the process, simplified language (e.g. no talk about u-values or air-leakages) and understandable contracts.

The authors suggest that skilled project managers, who may or may not have other roles in the consortium, and the use of a smart digital solution that attracts homeowners and facilitates a good collaboration between the various actors involved in the renovation process, were helpful.

Integrated service operators promote their value proposition to customers by raising awareness, gaining interested contacts, and arranging audit and advice through different channels, including personal networks, local renovation advice centres, social media, online search engines, public relations, their own websites, utility companies[134] and even through the trusted local post service in Picardie[135].

Energiesprong (Netherlands, France, UK, North America)

In the Energiesprong model[136], customers are offered a comprehensive whole-house retrofit, based on guaranteed net-zero energy consumption. The improvements are delivered and co-

[130] Mlecnik et al, 2017
[131] Volt et al, 2019
[132] Mlecnik et al, 2017; Mahapatra et al, 2013
[133] Mlecnik et al, 2017
[134] Volt et al, 2019
[135] Vest Conseil et Finance, 2018
[136] Brown et al, 2019; Brown et al, 2018

ordinated by a single organisation, which takes responsibility for project delivery. The model does not prescribe any specific technical measures but rather the performance outcome. It focuses on the social housing sector, so achieving scale is considered to be easier because multiple homes can be retrofitted under a single deal, whilst the customer interface involves a single product offering.

Another different emphasis is on the home improvement value of the whole-house retrofit. Homes are given a visual uplift and the retrofit typically includes a number of non energy-based maintenance measures; less emphasis is placed on energy cost savings, and more on health and comfort benefits alongside property improvement value. Customers are offered a comprehensive whole-house retrofit. This typically involves offsite manufactured, insulated facades, integrated with renewable heat sources and PV panels. The contractor offers a 30-year energy performance guarantee for net-zero annual energy consumption amortised over the calendar year. This is based on a guaranteed internal temperature of 21C in living spaces, and a set allowance of hot water and electricity consumption; analogous to a mobile phone contract with usage limits. The aim is also to reduce the duration of the retrofit to under one week using offsite manufacture and modularisation.

Brown et al reported that the Energiesprong initiative has emerged from its pilot phase and has now begun a period of growth and expansion to other national contexts - having signed a deal with 175 housing industry partners in the Netherlands to deliver 110,000 net-zero energy homes by 2020. The expansion to other countries has included the creation of market development teams in the UK, France, Germany and in North America, building on the Dutch experience. At the time of Brown et al's work, 4,500 net-zero energy homes (a mix of new-build and retrofit) had been delivered in the Netherlands, with 10 retrofits completed in the UK and 24 in France - with many more planned. The initiative was initially entirely state funded, and is now supported by national and European Union innovation funds and a range of local authority, industry and public sector partners in these respective countries[137] (.

However, radical business models such as Energiesprong's net-zero energy retrofits are contingent on a range of system wide changes which are yet to be fully observed. These include:

- Developing an industrialised supply chain to deliver scale economies sufficient to make the financial model self-sustaining.
- Developing innovation in long-term, low-cost finance mechanisms.
- Generating household demand, which will be vital for the model to become widespread.

One Stop Shops in France

Rahola et al., 2014 conducted a literature review and two case studies of renovation projects procured by Social Housing Organisations. They found that manufacturers and distributors can be influential in setting up sales agents within design-build-maintain contracts for project delivery in social housing in France, if they believe that increased sales of more effective and more profitable energy-efficiency products will result. These sales agents get performance-based incentives (commission) for sales within specific territories. These are defined against clear, realistic, but ambitious minimum requirements for energy savings. Key aspects are:

[137] Brown et al, 2018

- Clear and measurable award criteria that stress the importance of achieving high energy savings.
- A guarantee mechanism that is fair and robust.

However, in order to profit from these potential benefits, the scale of the contract must be large enough to ensure that any compensation paid to non-selected candidates does not adversely affect the total cost of the project. (French law requires there to be a minimum number of candidates that are invited to participate in the negotiation phase.) Also, the social housing operator's maintenance strategy needs to be flexible enough to operate maintenance contracts that are project-related as well as straightforward maintenance .

Killip et al., 2013, investigated a new company with a co-operative structure offering guaranteed performance contracts to clients for its refurbishment services. The company is run by its founders with the assistance of consultants for certain kinds of office support (e.g., information technology and marketing)[138]. The contractors doing the refurbishment works are all members of the co-operative, as are the clients. This structure is designed to maintain a balance of voices in the ongoing development of the organisation – both operationally and strategically. Start-up finance for the co-operative was supplied by EdF, but the co-operative governance structure ensures that control is not in the hands of a single large shareholder, but is shared between all, regardless of the size of each financial stake. For contractors, co-operative membership is conditional on key personnel being trained under the Eco-Artisan programme[139]. The contractors themselves operate a form of quality control through regular review meetings, in which any concerns about the quality of a member firm can be discussed and action taken. Ultimately, the co-operative has the right to throw out any member who consistently fails to meet the commitments of the contractors' charter, although the preferred course of action is to raise the quality of such members' work through encouragement and training. The traditional client role is extended in a striking way where energy-consuming behaviours are contractualised as part of the renovation performance guarantee.

Cost has long been considered a barrier to greater energy efficiency (based on cost-benefit analysis of capital outlay versus energy cost savings). In their review, Killip et al. identified a different kind of cost-benefit analysis: one in which the costs of greater professionalism and an increased level of turnover in the refurbishment industry might be offset at least partly by the benefits of greater labour and resource productivity. The calculations are both measured in monetary terms, but the input and output variables are very different from what is normally thought of when we talk about cost-benefit analysis for residential energy efficiency investment.

While cost is clearly an important factor, it is not the only one. A recurrent and over-arching aspect of the discussions with innovators in the field of low-carbon refurbishment has been the need to ensure quality. 'Quality' itself refers to several domains: quality of physical work, quality of design, quality of communication, and particularly is seen to relate to insulation, thermal bridging and air tightness. There is a tacit agreement among innovators that all of these areas need to be improved simultaneously[140] This research suggests that a much more concerted effort for systematic learning is needed to build skills, knowledge and experience of workable solutions across a wide range of industry actors. The case still needs to be made for the importance of feedback from monitoring of pioneering renovation projects. Despite its importance, we have not found any evidence of systematic learning from monitoring and

[138] Janda et al, 2014
[139] Killip et al, 2013
[140] Ibid.

evaluation projects, and these feedback mechanisms are of crucial importance to a model of Market Transformation.

Another case reviewed by the same research team[141] was a small firm[142] providing thermal energy design services, covering strategies to reduce thermal energy demand as well as specifying systems to meet that demand: a bureau d'étude thermique (BET).

This particular BET has wide experience of multiple low-energy projects which has led them to conclude that there is a need for: (1) an integrated approach to project management, including the oversight of cross-cutting elements of the refurbishment work (such as achieving airtightness standards); and (2) a mechanism for feeding back monitored energy data from the occupation stage of one project to the inception and design stage of the next. Cross-cutting elements and feedback loops for learning are not common practice, but the technical requirements of achieving real low-energy renovations (as opposed to modelled outcomes) make both of these new practices essential.

Janda et al., 2014, also reviewed a firm, Pouget, which has developed a multi-skilled method for insulating the interior of cooperatively-owned blocks of flats. This multi-family living arrangement poses a collective action problem, as all flat owners would have to jointly agree to pay to upgrade the exterior of the building and to insulate it externally. Individual flat owners could decide independently to insulate the interior of their own flat, but hassle and disruption of internal building works could be a barrier. Pouget offered an innovative service that minimises this hassle by taking detailed measurements in one site visit, cutting materials offsite, and using multi-skilled workers to complete the installation. Their quick fit internal insulation installation took only 10 hours to complete on site and raises the energy rating from an "E" to a "C".

Vesta Conseil et Finance, 2018, reported on how the Normandy region set up a coordination scheme to promote interactions of 3 clusters of professionals who agree to interact and participate in the Region's scheme:

- Energy auditors, thermal engineers, architects
- Construction companies and craftsmen
- Financial institutions and insurance companies

There was a regional incentive scheme (an eco-energy voucher), which was conditional on an audit conducted according to a regional charger and subsequent works being performed by chartered professionals.

Another French project found in the evidence base is a regional Service Public de l'Efficacité Energétique (SPEE)[143]: Picardie Pass Rénovation. The services for homeowners include information and renovation works advice given by the delegated project owner and a financing scheme. The operator offers loans of 15-25 years depending on the equipment and renovation works financed, the householder's ability to repay and the expected energy savings. The services offered to building contractors include procurement expertise, project management to assist the first renovations and a link with the regional cluster on eco-construction.

[141] Janda et al, 2014
[142] Approximately 30 employees, but growing.
[143] Vesta Conseil et Finance, 2018

Picardie Pass Rénovation is fully controlled by the Region, and contracted with each local authority in the region to organise the relationship and activities with the local advisors who were already funded, by the local authorities and ADEME, the French Environment and Energy Management Agency, to raise awareness among consumers and deliver them free advice. Then it launched public tenders to recruit local partners to carry out an orientation stage and to accompany homeowners through the further steps of the refurbishment journey. Tenders were allotted according to different districts, so as to make it easy for local associations (which are usually the employers of publicly funded advisors) to respond at least for their local district. The terms of payment were composed of 1. a fixed sum to cover the marketing tasks, 2. "per contact" tariffs for the engagement of homeowners up to the stage of the on-site visit and energy audit, and then up to the proposal of refurbishment works.

There is further evidence from two reports describing the Oktave initiative in the Grand Est Region of France[144]. Oktave is a new 'semi-public' company founded by the Regional government and ADEME. It collaborates with local authorities and local contractors and also helps to set up the financing plan for the works. This can combine grants, tax rebates and commercial loans, including offers from banks and energy service companies. It offers technical renovation advice tailored to specific buildings and project management assistance throughout the renovation process and for two years after its completion, through a single point of contact for the customer. The Oktave advisor puts together the most appropriate renovation package for the site, from the relevant building professionals. Its revenue stream is through a service package, which is billed to the customer. It includes training of professionals in both technical and customer sales skills, and maintains a directory of those who have been trained, who are then entitled to conduct renovations within the Oktave system. By 2017 250 building professionals had been trained. It was financed by a €1.5 million starting grant from the Grand Est Region of France (representing 50% of the capital of the company).

BetterHome (Denmark)

BPIE, 2017, undertook a descriptive qualitative analysis of selected integrated renovation services to understand their strengths and weaknesses These included BetterHome in Denmark, which was also reviewed by Volt et al., 2019.

BetterHome works with 3,500 installers from 105 organisations, and has been funded by four Danish manufacturers (Danfoss, Grundfos, ROCKWOOL and VELUX). Energy savings of 30-70% have been achieved for householders.

Volt et al., 2019, commented that there is a risk that if manufacturers fund the operation, they are not seen as impartial, but BetterHome in Denmark has been successful with this balancing act, partly because the Danes view these companies positively and associate them with quality products and local jobs.

BetterHome partners with key players in the construction value chain to deliver a comprehensive one-stop-shop solution. These include financial institutions providing mortgages, utility companies with energy saving obligations, local governments and real-estate agencies, as well as building professionals and installers. In this service-oriented model, the home-owner is offered tailor-made solutions based on his/her specific preferences. These may include energy improvements to the building envelope and heating, cooling, ventilation and hot water systems inside the building[145]. The process is holistically-planned, optimising the value chain by minimising efficiency losses and miscommunication issues and avoiding lock-in

[144] BPIE, 2017; Boza-Kiss and Bertoldi, 2018
[145] BPIE, 2017

effects. The research found that the success of the home-owner-centric business model could be explained by the advanced service-oriented role of the installers. BetterHome trains and guides the installers on how to approach the homeowner, from the first contact to the end of the process. In support, BetterHome also simplifies and structures the renovation process for the installer, through supportive and innovative digital tools, enabling a better process for all involved.

There are no payments between BetterHome and the installers or the building owners. BetterHome receives its whole budget from the four manufacturers who, in return, get indirect sale revenues. While BetterHome and its owners have an incentive to increase the sales of their products, the installers are not obliged to exclusively sell these brands. In the end, the renovation contract is only between the building owner and the installer.

A single installer is responsible for the whole renovation process and coordinates with the other installers involved in the renovation of the same property, allowing for better planning and building trust with the homeowner. The installers can also share relevant information on the renovation project via BetterHome's digital platform, creating a leaner process.

BPIE, 2017, found that in Denmark, quality assurance is heavily regulated in comparison to other European markets, including guarantees for the building owners. Furthermore, the financial subsidy scheme for energy renovations in Denmark is modest and rarely decisive for the building owners' decision to invest. In countries with substantial public support schemes for energy renovations, this can be incorporated into the business model.

Passivhaus (Netherlands)

Rovers, 2014 undertook a detailed review of a retrofit pilot project for 150 houses in the town of Kerkrade, driven by the Passivhaus Standard, with an aim to create living without energy bills. He found that the value from such a project was the learning and continuous improvement that occurs in several realms: construction management, financial planning, effective use of resources, skill development within construction firms and the apportioning of responsibility for actual outcomes.

The objective was to undertake the retrofit while the homes remain inhabited. This required the process to be very short. The initial aim was eight days, but this was later changed to ten days. This required very close cooperation between all construction parties and all the subcontractors were involved from the very first stage of the project. The technical target for retrofit to the Passivhaus Standard required both very good detailing and careful working on site (for air tightness, for instance). Several parties from the construction world were invited to discuss the construction possibilities at an early stage. Different ideas were sought and jointly explored while the project could still be restructured. This led to the decision that only consortia representing all the disciplines needed could do the job, due to the high requirements for cooperation and coordination, and the tight timing of all works of subcontractors to the job.

The high level of ambition for energy reduction, combined with the tight schedule, increased the risk of failure. Normally, the client owns these risks. However, in this case, performance contracting is used: the partners in a consortium that were jointly responsible were assigned the responsibility for the energy performance of the project. Furthermore, the responsibility remains with them for a certain period after completion. This ensures that the consortium partners have an interest in the whole project. In the end, four consortia tendered, with the required innovative approach including financial, technical and organisational plans, aimed at far-reaching cooperation in the total chain of suppliers.

The actual work pattern was the main innovation in the project: ten days per house in a continuous process. It was like an assembly line for cars, only the other way around: the workers moved past the houses, performing their particular job case by case. The whole train of activities moves one house a day, so at any moment you can see all stages of the process simultaneously. To limit nuisance for the inhabitants, as much of the work as possible was performed from the exterior. For this, the inhabitants were asked to move their furniture 0.5 m away from the front and rear facades. A temporary plastic wall was inserted to provide protection and to create a small working space for the builders.

In spite of extensive planning, and working as a co-maker group, many difficulties arose during the first few days. These included achieving timely deliveries, cleanliness on site and clean ways of working, organisation of the site and working as a team, as everything depended on a tight cooperation. With these problems, it was not a surprise that the schedule slipped during the first days/projects.

The inhabitants found this unacceptable. Ten days of chaos was the most they would tolerate. But after the tenth house, the construction process was actually working to schedule. After a learning curve on the first ten to 15 houses, the target of ten days per house was realised. It required many innovative approaches. For instance, the scaffolding was built in standard house-high elements, so that a crane could move it from a finished house to the next in line in just three moves. The actual energy performance is being monitored in 65 houses with data from their digital energy meters.

The housing corporation is in negotiation with the tenants about further, more detailed monitoring and research on rebound effects etc. Unfortunately, the tenants are reluctant to cooperate as they are now happy that the ‘chaos’ is over.

It was important for the construction consortium to take responsibility and ownership of energy performance. This new project model showed that it was possible for construction firms to provide performance guarantees and pointed to a new direction: the need for RESCOs (retrofit service companies). These organisations would take responsibility for energy performance as well as maintenance, can integrate renovation and energy measures at the same time and can provide this service for 25 years or so. The need for RESCOs is even more apparent when the process moves from social housing projects to the private housing sector where there are millions of individual owners. This would provide credibility, reliability and certainty to private owners.

REAQ2 evidence synthesis: secondary questions

What stakeholders operate within the retrofit supply chain?

Evidence from the US[146] summarises different roles as follows:

- **Manufacturers:**
  Manufacturers are interested in promoting new products or promoting market position for products that perform well. They also might have larger profit margins on newer models than for baseline equipment, to recoup R&D costs. Thus, a large-scale utility programme - especially one guaranteed to last for a long time and / or one covering a large region - is sufficient motivation to participate. In most cases, manufacturers can be

[146] Merson et al, 2018

the greatest ally in launching a midstream programme. They can identify regional distributors, extend longer credit terms or waive restocking fees for distributors / wholesalers, and obtain sales and product data that help create a value proposition for other supply chain actors.

- **Manufacturers' Representatives:**
  This link in the supply chain is typically a person, sales agency, or company that brings a manufacturer's products to wholesale and retail customers. The manufacturer hires the "rep" to act as an agent in selling, or soliciting sales for, its products in a targeted territory. In return, the rep receives a commission for products sold downstream in the supply chain. The rep is necessary to the supply chain - and can help speed delivery of an efficiency programme - when the manufacturer has no sales force or when it is more efficient or lower risk for them to use an alternative route.

- **Distributors / Wholesalers:**
  Distribution is a high transaction-oriented and cash flow-aware business model. Distributors can elevate inventories when they expect increased demand from a programme, and provide sales and marketing support, with product and programme training to regional trade allies. Distributors also offer crucial lines of credit or beneficial financing terms to the trades. Utility programmes benefit wholesale distributors by moving customers from baseline products with lower gross profit dollars to energy-efficient products offering larger gross profit dollars (and in many cases, higher gross profit margins), increasing the volume and velocity of sales, reducing receivables turnover and other risks, and proving insights that can help improve the organisations' market strategy and positioning.

- **Contractors:**
  Whereas distributors profit best on the volume and size of transactions, contractors profit from the amount of service they provide to a customer. To benefit trade allies, this means adding controls and a maintenance contract to equipment replacement and charging more for high value knowledge and capabilities. Moreover, it follows that utility programmes should create incentives and track metrics pertaining to the scope and quality of customer services. Programmes can help participating contractors win more work by elevating and distinguishing their brands with customers. However, it is also critical that utilities require the correct licenses, insurance, and training and certifications. It is important too to remain product neutral or service-neutral. Thus, typical program interventions are:

    - Offering training to contractors (including in partnership with manufacturers, manufacturer representatives and distributors).
    - Allowing contractors to display completed coursework and certifications on utility websites.
    - Providing performance-based incentives.

An alternative classification from a European multinational study[147] is:

- Partners who provide renovation services (product and material suppliers, subcontractors for missing disciplines).

[147] Mlecnik et al, 2019

- Partners who can effectively reach possible clients (networks, local non-profit organisations aimed at sustainability, homeowner associations, hardware stores).
- Local/regional/national authorities for supporting policies as well as providing subsidies (municipalities or provinces, energy agencies, organisations offering subsidies).
- Financial supporters (banks and public authorities offering specific loans for energy efficiency measures, innovation agencies).

How do different members of the supply chain interact with each other?

Mlecnik et al., 2019, found that within integration models all consortia emphasised the need to provide an initial analysis or energy audit as a solid foundation for the decision-making process. However, in most consortia, it was difficult to identify how the advice would be financed as homeowners are usually not willing to pay for such energy advice, and how the advice could be given by 'independent' advisers that are trusted by homeowners.

In the case of Energiesprong in the Netherlands, Brown et al., 2019, found that delivery of a net-zero energy retrofit requires an integrated supply chain, typically with a single 'solution provider'. The Energiesprong model therefore adopts a performance-based approach to procurement: Project Managers ask for a product performance to a fixed price point. Hence there may be a need for both legal and financial skills within the integrated supply chain.

In another case in the Netherlands[148], performance contracting was used: the "co-makers" (i.e. the partners in a consortium that were jointly responsible) are assigned the responsibility for the energy performance of the project and the responsibility would continue to remain with them for a certain period after completion. This ensures that the co- makers have an interest in the project. Workload planning was an important aspect; it would have been very ineffective to have the workforce needed only temporarily for specific tasks. Tasks were organised to enable each worker to do a full day's work.

Nösperger et al., 2011, found that French tradespeople see product manufacturers as relevant to support craftsmen in their efforts to change, whereas energy suppliers just bring commercial help (which already exists). On the other hand, official energy efficiency institutions (ADEME or local energy efficiency institutions) are ignored.

In Normandy, the Region set up a coordination scheme based on interactions of three clusters of professionals who agree to interact and participate in the Region's scheme (Vesta Conseil et Finance, 2018):

- Energy auditors, thermal engineers, architects.
- Construction companies and craftsmen.
- Financial institutions and insurance companies.

Normandy Region realised that local credit brokers were more receptive to the Region's clustering efforts than banking networks, which have more constraints regarding their marketing and offerings. Also the Region makes its incentive scheme (an eco-energy voucher) conditional on the fact that works are performed by chartered professionals further to an audit which has to be conducted according to a regional charter.

[148] Rovers, 2014

How do retrofit supply chains identify their market?

In a study of 24 active consortia in Austria (5), Belgium (5), Netherlands (5), Norway (5) and Germany (4)[149], almost all consortia defined the customer segment as homeowners with an above average income. This is based on their understanding that a major renovation requires a high upfront investment, which lower-income groups often cannot fund and which the consortium cannot facilitate easily. A majority of the consortia classified their most promising customer segments as young families moving to a larger home. Only a few consortia specifically wanted to target older homeowners, for example “empty-nesters”. About half of the consortia looked at types of houses according to age. Clearly the energy efficiency measures, the insulation performance and available HVAC systems of a dwelling strongly relates to the individual building’s construction year. This typically led to highlighting the houses constructed before 1980, but with some country differences as the age of the local building stock varies. Consortia that had studied statistics on the local building stock selected a certain well-defined period, in order to specialise and develop solutions for specific building typologies, to aim at mass production. Most consortia defined a geographical limitation of their market; typically a radius of 50 km.

Another study of One Stop Shops (OSS)[150] notes that the energy renovation market is still at a very early market phase. Therefore it is innovative and open-minded householders who are most likely to agree to a holistic renovation project. This is an expensive investment and so potential buyers must have capacity to finance the investment, for example by increasing their mortgage. The operational radius of the OSS defines the geographical location of the potential. Another relevant criterion is how long the potential customer has owned the house; a homeowner in a house for several years may have greater scope to finance energy renovation with a remortgage.

One case study from two regions of France[151] found that La Poste, the French national mail service, had developed a database for targeting households that might be interested in a renovation project, in partnership with energy efficiency services operators set up by Regional governments[152]. This offer, named “DEPAR” by La Poste, comprises four distinct phases:

- Households were targeted using a mapping tool developed by La Poste (combining data from the national EPC data base, or from a pre-existing client file).
- A team of postal workers each made two visits to identified dwellings, to present a flyer outlining the regional service and for householders to respond to a short questionnaire, to evaluate their motivation for renovation. On householders’ agreement, postal workers then set an appointment with a technical advisor from the service to make a general audit of the house.
- La Poste priced this service based on its achieved performance (i.e. the number of appointments secured).
- The information and campaign results were transferred to the regional energy efficiency service operators.

[149] Mlecnik et al, 2017
[150] Mahapatra et al, 2013
[151] Vesta Conseil et Finance, 2018
[152] Picardie Pass Renovation and its equivalent in Nouvelle Aquitaine, ARTEE

La Poste Group was seen to be particularly successful in reaching households in rural regions. As local and trusted actors they are also able to give messages to local residents about the energy renovation, engage contacts and deliver good prospects to the operators.

How are retrofit services advertised and sold?

Multi-country research of consortia in Austria, Belgium, Netherlands, Norway and Germany[153] found that all consortia understood that, compared to selling single low-carbon technologies, there has to be a specific reason for introducing the concept of an integrated home renovation. For example, if the house needed a facelift, or there was a 'change in life' situation, with a requirement for more space or better accessibility. Targeting particular customer segments usually reflected this. All consortia also targeted the 'soft needs' of renovation, such as providing better indoor comfort, environmental aspects, increased home safety or financial security for old age.

The Energiesprong study[154] noted that the traditional offer to households has been framed in terms of energy cost savings, rather than home improvement or increasing comfort. This was considered to be a mistake by many of those interviewed: "For most people … it's not the economics that's driving them, it really isn't. First and foremost, it's comfort, it's often aesthetics, what you perceive as aspirational… It's all these subtle things that are more cultural I think". For Energiesprong itself, less emphasis is placed on energy cost savings, and more on health and comfort benefits alongside property improvement value. The financial model uses an energy performance contract structure to fund retrofits. The Lender captures the energy savings and charges this back to the property owner based on historic consumption. The retrofit supplier assumes responsibility for payment of the energy bill.

A comparative assessment of existing and proposed OSS's in the Nordic countries noted that, in some examples, local meetings were regarded as very important to motivate customers for energy renovation and this enables them to become more engaged and to perceive how the work can be done within their own budget. Involvement of known public bodies as partners to OSS companies encourages engagement[155]). Research in Sweden amongst owners of 21 construction SMEs[156] found that the companies used word of mouth to access more customers, and good references from past collaborators to get new projects. The vast majority of interviewees claimed that it is a common practice, when they are called to do some technical work, that the customer asks them to do additional work. For this work, they usually suggest other contractors within their network of collaborators.

In the US case of the BBNP[157], grantees used traditional approaches such as print media and television to generate interest in the programme. However, converting interest into actual retrofits required a more personal approach to outreach, typically centred on Community-based social marketing using local networks and trusted messengers to address barriers at the level of the social group. Some programmes provided sales training for contractors with the aim of increasing conversion rates, and one programme introduced marketing and behavioural science training in its outreach strategy. One state provided contractors with sales and financial training to help them sell financial products, which is outside their core area of expertise.

[153] Mlecnik et al, 2019
[154] Brown et al, 2019
[155] Mahapatra et al, 2013
[156] Pardalis et al, 2019
[157] Gillich et al, 2018

Is the supply chain for retrofit trusted by consumers? If so, why? How has this trust been gained?

A Netherlands study to assess decision-making processes and how trust plays a role involved 40 depth interviews with home owners who had paid for low carbon retrofitted measures[158]. It found that trusted advisors played a role in four phases of decision making: orientation; customised advice; requesting and comparing quotes; and installation, evaluation and confirmation.

The share of consumer respondents mentioning impartial mediators (e.g. NGOs, consumer organisations, certification schemes) was 50%, 30%, 53% and 35% for the four phases respectively. The share of respondents mentioning professional mediators was 0%, 45%, 40% and 60% respectively.

In cases where individuals trusted the building or project manager's choices, the stakeholders' ability to recommend an ambitious energy-efficient retrofit was decisive[159].

There is no further evidence on the remaining secondary questions:

- What factors lead to successful upselling of further retrofit measures?
- How do supply chain members interact with home assessment measures (such as the EPC or equivalent)?
- How do supply chain members interact with local government regulations (such as planning permission)?
- How does the supply chain interact with government schemes to promote retrofit loans/grants etc?
- How do supply chains interact across borders?

REAQ3 evidence synthesis: primary question

"*How do members of the domestic energy efficiency retrofit supply chain upskill in different countries?*"

Evidence base characteristics

Relatively few (13) pieces of evidence were found which were relevant to this topic, all dating from 2008 to present. No evidence on general building training is included: all sources relate to energy efficient/green/NZEB building, although not all relate only to renovation (7, another 6 also covered new build) and none relate only to domestic buildings.

The split of sources by country is shown in Table 4 (NB several studies described more than one country so the total is more than 13). 19 countries are covered, all but two (Canada and USA) are in the EU.

[158] De Wilde, 2019
[159] Beillan et al, 2011

Table 4: Evidence synthesis by country for REAQ3

Country	No of grey sources	No of white sources
Austria	1	0
Belgium	1	0
Bulgaria	2	0
Canada	1	0
Croatia	1	0
Czech Republic	1	0
Finland	2	0
France	0	1
Germany	1	0
Greece	1	0
Hungary	1	0
Ireland	1	0
Italy	2	0
Poland	1	0
Romania	1	0
Slovenia	1	0
Spain	1	0
Sweden	1	0
USA	7	1

This evidence suggests that the interest in Vocational Education and Training (VET) for energy efficient buildings has been driven by three main interests, all of which may apply:

- The need to increase the size of the skilled workforce in order to provide new build or renovated buildings to meet climate change targets[160].

[160] See, for example, Blomsterberg, 2013

- The need to improve the skills of the existing workforce so that they can work with the new, low or zero carbon technologies and build or renovate to the high standards required[161].

- To meet socio-economic requirements - to diversify the workforce to increase the number of women and non-white representation[162], to provide a route to skilled employment for a part of the population which struggles to find work[163] or provide work in an area with high unemployment[164].

Most of the evidence focuses on the training provided; but some sources cover related aspects. One source looks at funding/operation[165], one describes the training and, qualitatively, the results[166] and one is a formal evaluation[167]. Most of the evidence is concerned with training outside full time education, although some included that in schools, colleges or Universities[168]. Most of the training is technical in nature but some is in sales, marketing and customer service[169].

The evidence is summarised below. First, the evidence describing training is set out, and then the evidence from evaluation of training courses. The descriptive evidence is organised into multi-country studies, studies looking at one specific country and studies considering regional or local training within one country (the USA).

Evidence describing training

FIT-TO-NZEB (Multiple countries)

The EU Horizon 2020 (H2020) funded FIT-TO-NZEB project was designed to increase the competence and skills of building professionals in the field of retrofitting to NZEB-levels in the target countries (Czech Republic, Romania, Bulgaria, Italy, Croatia, Ireland, Austria and Greece). The required educational programmes were developed by the consortium, and it was hoped that these would contribute to both the quality and the scale of deep building energy renovations. As reported by Center for Energy Efficiency, 2019, training was developed at three levels:

- **Universities:**
  The objective of the Fit-to-NZEB programme is to extend knowledge in the field of design, building and use of buildings. The development of the educational programme for levels 6-7 under the European Qualifications Framework (EQF) was the cornerstone for implementation of this topical area of the project. It covered the full range of learning outcomes relevant to deep energy retrofit. The model programme is divided into 60 hours (30 hours of theoretical lectures and 30 hours of practical seminars) in which 17 topics are taught.

  3 courses were created in universities which specialised in Architecture, Construction

[161] See, for example, Mikkonen et al, 2011
[162] See, for example, Shoemaker and Ribiero, 2018
[163] See, for example, Foshay, 2012
[164] See, for example, Ferguson, 2018
[165] Le et al, 2012
[166] Dandridge et al, 2010
[167] Opinion Dynamics Corporation et al, 2009
[168] See, for example, Mikkonen et al, 2011
[169] Ferguson, 2018

and Engineering, targeting EQF levels 6-7, with a total of 99 students involved. The countries participating in this element were Bulgaria, Croatia, and the Czech Republic.

- **Professional high schools and colleges:**
  The proposed training programme 'Deep Energy Retrofit: Retrofitting to nZEB Levels' is conceived as an additional module to be introduced in the curricula of Construction and Architecture Professional High Schools and Colleges. Specific units of learning outcomes are also applicable in the curricula of the corresponding educational institutions in the area of energy and mechanical engineering. The model programme is divided into 60 hours (24 hours of theoretical lectures and 36 hours of practical lessons) in which 21 topics are taught.

  This element of the project included five courses in professional high schools and colleges, targeting EQF levels 3-5, with a total of 120 students involved. Two courses were in Romania, two in Bulgaria and one in Italy.

- **Vocational Training Centers:**
  The project has developed training programmes for EQF Levels 3 to 4 for the two streams of construction workers involved in the deep retrofitting of buildings: 1) Building envelope (including bricklayers, carpenters and plasters); and 2) Mechanical systems (including electricians, plumbers and those working in the HVAC sector).

  Different training programmes are envisaged depending on where the training might take place, as follows: 1) Delivered at a vocational training centre - this would be a training centre where models of deep retrofitting are available and where hands-on experience is provided; and 2) Delivered at the construction site ('on-site') – this would be where training is delivered at a construction site of a deep retrofit project, making it more convenient for the construction workers to attend and also helping to solve 'real-problems' which they might be experiencing on any given project.

  Lastly, different lengths of courses are envisaged depending on the knowledge and skills level of the construction workers involved, as specified below: 'Full-time training', amounting to 40 hours, 'Upskilling', amounting to either 16 or 24 hours, and 'Validation', amounting to 12 hours (the focus of which is directed to validating skills and knowledge of already-experienced construction workers). The project has included 18 courses in vocational training centres, aiming to upskill / provide additional qualifications to a total of 353 trainees at EQF levels 3-4. This element of the project operates in Bulgaria, Romania, Italy, Greece, the Czech Republic and Ireland.

VET4LEC (Multiple countries)

Clarke et al, 2019, looked at the ways in which different European countries (Belgium, Bulgaria, Finland, Germany, Hungary, Ireland, Italy, Poland, Slovenia and Spain) develop the knowledge, skills and competences needed for low-energy construction (LEC) within their varying Vocational Education and Training (VET), industrial relations, legislative and construction site contexts and in particular with regard to exemplary case study projects.

They found that the VET system is generally better equipped in Belgium, Finland and Germany compared to the other seven countries in the study, providing a more stable base from which to develop VET for LEC. In Bulgaria, Hungary, Ireland, Italy, Poland, Slovenia and Spain, the Build Up Skills (BUS) investigations suggested that the existing VET system was a barrier.

For these same countries, with the exception of Italy, the BUS national reports show LEC elements within mainstream IVET to be either completely lacking or very limited and mainly catering to technical/building services occupations. More training was reported within CVET, organised by a combination of further education organisations, technical colleges, and private providers (training providers, construction companies or manufacturers of energy efficiency or renewable energy related systems and materials), with most courses in renewable energy installations. However, overall, CVET was found to be fragmented and not co-ordinated, limited in occupational range and geographical reach, with most courses at higher levels and catering to those with some existing technical training. A general lack of awareness of energy efficiency within the construction sector, including amongst employers, workers, policy makers and the general public was also noted as a barrier to increasing demand for LEC and related VET.

Table 5 provides a summary of some features for each of the countries profiled in the report.

The report includes summaries for individual countries – the interested reader is referred to the report for more detail.

Table 5: Summary of features by country

Country	Involvement of social partners	Main funding sources IVET	Main funding sources CVET	IVET features	CVET Features
Belgium	Strong	State and employer	Employer and employer organisations	No specific detail listed	No specific detail listed
Bulgaria	Weak	State	Ministries, municipalities, employer and employee organisations and individual employers	No specific detail listed	May be informal
Finland	Weak	State	Not listed	No specific detail listed	Qualifications can be earned with skills examinations. 70-80 % of learning taking place at work. Most apprentices are adults.
Germany	Strong	Employer levy and state funding	Not listed	Provided in a company (practical), in a training centre (workshop, simulated learning) funded through the levy, and at a vocational school	There is a nationally regulated CVET system that builds directly on IVET and leads to recognised qualifications, equivalent to university degrees or masters
Hungary	Weak	State	Not listed	No specific detail listed	There are some mandatory CVET programmes for a given occupation

Country	Involvement of social partners	Main funding sources IVET	Main funding sources CVET	IVET features	CVET Features
Ireland	Weak	State and employer	Not listed	No specific detail listed	CVET range from one-day courses by private companies to comprehensive 3-year programmes
Italy	Medium (national and regional)	State	Financed with contributions deriving from the sector	No specific detail listed	No specific detail listed
Poland	Weak	State	Not listed	VET is not popular because it is a relatively long, theory-based education with little financial returns and employers, in turn, claim that VET schools do not prepare students for the construction site	Fragmented and limited
Slovenia	Medium	State	Not listed	Choice of technical or vocational	A substantial part of CVET training is competence-based training, leading to NVQs obtained through competence-based accreditation of prior experiential learning

Country	Involvement of social partners	Main funding sources IVET	Main funding sources CVET	IVET features	CVET Features
Spain	Strong	State	A quota paid by companies (0.6%) and employees (0.1%) on their salary payroll	involves work-based learning (20%), together with practice in a workshop (32%) and theoretical learning in the classroom (48%)	No specific detail listed

France

In their analysis of case studies of innovative building practice in France, Janda et al, 2014, include a description of two accreditation schemes for skilled practitioners, each supported by a different trade association. The first of these is the “éco-artisan” scheme, supported by the Confédération de l’Artisanat et des Petites Entreprises du Bâtiment (CAPEB). The second is the “pros de la performance énergétique” scheme, supported by the Fédération Française du Bâtiment (FFB). France has pioneered the QualiBAT voluntary training programme for building-related trades, and two programmes for microgeneration and low-carbon conversion technologies (QualiEnR for renewable energy and low-carbon technologies; and QualiSol for solar installations).

Sweden

Blomsterberg, 2013, describes the then current status of training in Sweden on energy efficient buildings. They describe national training available in secondary education but found training beyond this limited to local courses and training programmes, specifically:

- Passive House Centre in Alingsås organises the course ‘Passive house builder’ for construction workers. The course provides general and broad basic knowledge of the building of passive houses and energy efficient buildings. In addition to energy efficiency, course participants learn to regard the building as a system where good indoor environment and good durability are important properties. The participants should gain a full understanding of energy-efficient building and the requirements of quality and control that are needed, knowledge of the problems that may arise and how they can be prevented, and knowledge of building as a system. The course takes two days. Day 1 includes the passive house concept, building as a system, certification and requirements, airtightness, moisture, thermal bridges, windows and doors in passive houses, and ventilation. Day 2 includes a practical workshop (pressurisation, thermography and moisture measurement), review, discussions and plan, evaluation and a theoretical and practical exam. The number of participants is 20–25 per year.

- Individual operators may have their own courses, e.g., the contractor NCC has a ’Moisture and energy training’ of four hours for production staff, which includes: Ongoing climate change, Design of low energy/passive houses, Airtightness, Moisture security, Construction details regarding moisture and tightness, thermal bridges and also lead-throughs.

- An example of the individual courses is the one-year continuing education for construction workers, ’Conversions and renovations for building craftsmen’ at Nässjö Academy. The course is for construction workers who want to specialise in renovations and conversions of modern houses and apartments. The subjects addressed are, for example, energy efficiency, conversion technology, economy, work environment, reception and design.

- There was an ongoing, recently started project, aiming to produce continuing vocational development for skilled workers within the building industry. Passive House Centre Västra Götaland (PHC) and SP Technical Research Institute of Sweden (SP) shall, within the project “Capacity building of skilled workers”, develop a vocational development programme within the field of energy-efficient building, based on the education of trainers. Knowledge dissemination will therefore largely be conducted through internal training within contracting companies, using course material developed within the project. This procedure creates the possibility to cost-effectively and speedily

disseminate knowledge to a large proportion of skilled workers in the building sector. The project consists mainly of two parts: the development of a continuing vocational development course for trainers at contracting companies and also the production of training material for this course. The overall goal of the project is to train approximately 30 trainers engaged in contracting companies with resources to maintain 2–3 internal training sessions during 2012. Through this procedure, one thousand skilled workers should have received training within a few years. The goal is to continue the education of trainers after this project has concluded with the help of the course material. This work will however be funded by course fees. The aim is to reach out to a greater section of Sweden's skilled workers within the building industry by 2019. The contractors NCC, Skanska, PEAB, the property owner Poseidon, and the Swedish Construction Federation are participants/co-financiers of the project.

- The management of skilled workers may also require continuing vocational development. At Stockholm Vocational Institute of Technology, there is an education in Low-energy buildings Engineer, lasting 80 weeks and eligible for 400 HVE (Higher Vocational Education) credits. The education is aimed at those working as, for example, Construction (Project) Manager.

Finland

Mikkonen et al, 2011, provide an overview of plans to ramp up energy efficiency education and training in Finland across trade, commerce and residential, with two case studies.

- The Buildings Regulations Department of the city of Oulu in northern Finland, in cooperation with the University of Oulu Department of Architecture and Oulu University of Applied Sciences, have started one-year continuing training on energy efficiency for building professionals, like architects, engineers, and planners in construction sector. Training consists of a series of lectures, study tours, business contacts and on-the-job-learning. The training course provides qualified professionals for energy efficiency tasks for local industry and service sector.

- Three technical universities have, in cooperation, started at the end of 2010 energy efficiency expert apprenticeship-type training for technical professionals with higher education. The one-year training consists of a series of lectures and apprenticeship-type training in their work-place. Training is offered to professionals working in engineering and consultant companies providing services to municipalities and industry.

Evidence describing training at a regional or local level in the USA

- Shoemaker and Ribeiro, 2018, used stakeholder interviews to look at local government related training schemes in 9 cities in the USA and Canada. They found a range of activity including: a Green Professional Operations and Maintenance (GPRO) Essentials course for professionals offered by the city of New Orleans; and a Career Readiness Training programme, provided to young adults in the City of Knoxville, on general concepts related to energy efficiency and weatherisation, as well as communications skills. In this second example, these youth ambassadors then helped raise awareness about the local Extreme Energy Makeover programme. Based on their review the authors recommended: engaging key stakeholders (including energy efficiency business and manufacturers); aligning training with local initiatives to generate demand for energy efficiency and consider diversity and equity issues.

- Ferguson, 2018, undertook a survey of energy efficiency training in rural America (specifically Maine, Appalachia, Alaska, Alabama and Virginia). In Maine the energy

efficiency programme invited contracting companies to training in sales, marketing and customer service. Following this the programme's assessment-to-upgrade conversion rate grew from 10% to 60%. A programme in Alaska provided intensive workshops and certifications for builders, contractors, and engineers focusing on design and construction of energy-efficient homes, retrofit techniques, and installation of mechanical ventilation systems, and in Alabama the programme provided distance learning options. In Virginia a programme is providing training for 'dislocated' coal miners whereby trainees can attain credentialed skills in four months rather than over the course of a year as in traditional retraining programs.

- Campbell et al, 2012, reviewed education and training efforts for existing workers through seven different Utility sponsored Energy Training Centers in California. They provide some statistics on the attendees, noting that 26% were Professional - Architect/Engineer/Designer, 23% Green Worker/Consultant, 13% trades and the rest other (including codes/standards and building/plant management). They surveyed attendees and found that 83% of participants advanced their career or received a career benefit from the Center, which included: (1) Received a pay increase; (2) Received a job promotion; (3) Advanced career within current company; (4) Helped to get into a new industry; (5) Helped gain new customers by offering new or improved services; (6) Helped stay competitive in the marketplace; (7) Helped to find a job or change jobs; or (8) Helped to deliver a higher level of service to customers. However, the authors were critical of the delivery of the training specifically:
    - Very few (1%) of the courses had learning objectives that reflected what class participants are expected to be able to do as a result of the training.
    - Most of the courses were very "content laden," with little time for participants to discuss and assimilate the information presented.
    - Only about half (52%) of the courses included any type of activity designed to allow participants to check their understanding of information or concepts or practice key skills.
    - Very few (1%) of the courses incorporated an assessment that would indicate whether an individual attained the training goals.
- Foshay, 2012, reviewed a Green Energy Training Services (GETS) programme in California which prepared adults for entry-level jobs in residential building performance. Crew members work under the supervision of a licensed general contractor and Building Performance Institute(BPI)[170] certified Building Analyst and receive case management and job placement support from GETS staff. In addition to technical skills, they develop soft skills, like showing up on time to work, behaving professionally at the job site, and working as a team. An Employer Council played a crucial role in the development of the training curriculum, providing significant input on which skills to emphasise. GETS curriculum has been approved by the Building Performance Institute and is aligned with testing requirements for four levels of BPI certifications: Building Analyst, Envelope Professional, Retrofit Installer, and Crew Chief. The majority of instruction is hands-on; the populations GETS serves are more likely to be kinesthetic learners [171], meaning that

[170] The Building Performance Institute, Inc. was founded in 1993 and has become the nation's (USA) premier standards development and credentialing organisation for residential energy auditing and upgrade work. BPI is a 501(c)(3) non-profit organisation.

[171] People who learn most easily from hands on experiences rather than auditory (listening) or visual – the latter two being most commonly used in most classroom training.

classroom learning is not the ideal way for them to master the material. They found that, since 2009, over 230 people have graduated from GETS; to date, almost seventy percent of GETS graduates have found employment, half of whom have found jobs in energy efficiency or related industries.

- Le et al, 2012, looked at how joint labour-management apprenticeships typically function, and how they relate to job quality, by examining schemes in Oregon and Washington. In the joint labour-management apprenticeship model, both contractors and workers contribute resources to a training fund. Through the collective bargaining process, employers agree to invest in joint labour-management administered apprenticeship programmes that offer intensive skills training. Contractors working in the field identify needs or opportunities for new construction materials and practices. In turn, Joint Labour-Management Apprenticeship Training Councils (JATCs) incorporate these new technologies and practices into their apprenticeship curricula to quickly prepare construction workers to face these changes in the industry in real time. Pre-apprenticeship programmes usually consist of training on basic maths, reading, time management, and other skills to equip potential apprentices with the skills to successfully qualify for and complete apprenticeship programmes. Pre-apprenticeship programmes work best when they are directly coupled with and connected to registered apprenticeship programmes so that pre-apprentices receive training in the specific competencies that the apprenticeship programmes require, and so there are clear pathways for pre-apprentices to enter these programmes by utilising the highly developed and existing joint labour-management apprenticeship infrastructure in the construction industry. Energy efficiency stakeholders can leverage existing resources, facilities, curriculum, and teachers to train entry-level workers and to help existing workers update their skills.

- Dandridge et al, 2010, reported two case studies, one of which related to energy efficiency –Energy Efficiency and Job Readiness Training for “At Risk” Older Youth: Green Workforce Internship Program in Marin county (San Francisco Bay area). They found that best practice involved:

    - Conducting a preliminary skills assessment test to ensure literacy levels are sufficient.
    - Working in collaboration with industry leaders to build relevant skills.
    - Providing an internship and field experience component to make future employment possible.

  Out of the 15 low-income youth participating in the programme, ten were offered jobs post internship, and seven of those ten were offered work in the thriving energy efficiency field.

- Gillich et al, 2018, undertook a review of the US Better Buildings Neighborhood Program (BBNP) which consisted of 41 different (regional or local) versions of thermal retrofit programmes with a common structure and objectives. They found many BBNP grantees increased success by emphasising non-technical skills training. Some programmes undertook sales training of contractors, to increase conversion rates, and one introduced marketing and behavioural science training in its outreach strategy. One state provided contractors with sales and financial training to aid them in selling financial products, which is outside their core area of expertise. Sales and marketing training proved beneficial for many programmes since contractors were often being called upon to sell products that were outside their existing expertise, including financial products.

Sales training also helps to distinguish clearly between the programme's strategies for marketing assessments and selling upgrades.

Evidence from evaluation of training

One piece of evidence, Opinion Dynamics Corporation et al, 2009, provided a formal evaluation to assess the indirect energy efficiency impacts of four Statewide (Californian) Energy Efficiency Education and Training Programs. The evaluation sought to understand the reach of the programme, identify changes in knowledge of energy efficiency, understand the behaviours that resulted from participating in the programme, and quantify net energy savings for key components of the programmes. (NB the programmes and the evaluation included courses for commercial and residential customers and market participants – only the latter are covered here, by topic.)

- **Heating Ventilation and Air Conditioning (HVAC):**
  Market actors who took the HVAC course(s) report that they have improved the quality of their work as a result of using different diagnostic tools, through the availability of new data and the refinement of their skills. In addition, they acquired new information that has allowed them to adopt new planning, design and installation practices.

- **Building envelope:**
  Based on interviews with market actors who took building envelope courses, it is clear that the courses had an important impact on their work by providing them with an improved understanding of home performance, as well as assistance in making recommendations and offering advice to clients, and also in changing their installation practices. Overall, 70% of market actors changed their practices as a result of the course. Almost half of market actors (47%) revealed that they recommend different energy efficient equipment or recommend energy efficient equipment more frequently as a result of the course. Changing their approach for sizing equipment (28%) and designing buildings differently (27%) were the next most frequently mentioned changes. An overwhelming majority (87%) of market actors have shared the information they learned in the course with a colleague, which could motivate the colleague to take energy saving action. In addition, 77% of market actors report searching for additional information related to the course.

  Market actors also indicated in the qualitative interviews that the networking at the course itself also has a positive effect. For example, as one market actor mentioned, "You know, there's interface that goes on among my peers at these things. I pick up a lot there too." 43% of market actors responding to the survey estimate that their changes resulted in measurable energy savings for their clients, with 15% classifying the savings associated with the changes as "significant."

- **Demand:**
  The research demonstrates that there is clear demand for ongoing education, given that 40% of participants took multiple courses. Among this group, the most common reason to take courses was to stay up-to-date on the practices in their field. When asked about the benefit of taking a series of courses, participants spoke about being better able to perform certain professional duties such as providing informed recommendations to their clients, as well as receive training on the use of energy analysis tools.

  The experience of the most frequent course takers illustrates the ability of Energy Center courses to help individuals transition into new areas of work or take on new professional responsibilities. While the majority of these participants report wanting or

needing to learn about energy efficiency to continue in their current profession, about one third made the decision to take courses to develop a new area of expertise or knowledge.

REAQ3 evidence synthesis: secondary questions

No substantive evidence was found on any of the secondary questions:

- Is retrofit part of a wider suite of skills or do the suppliers specialise?
- Is training usually undertaken on courses, or is it done peer to peer?
- How frequently do members of the supply chain train in new methods?
- How aware are the supply chain of new techniques?
- How is awareness of new techniques gained and spread?

Conclusions

Our conclusions from the REA were:

- The evidence is sparse – the effect of the supply chain involvement on energy efficiency retrofit has been studied little.
- No one country has a widely adopted approach which focuses on supply chain.
- Examples exist but are local or regional and not well documented.

Therefore, we recommended that Phase 2 needed to:

- Concentrate on specific, local examples and capture the learning from individuals involved in these schemes, to overcome the lack of documentation.
- Increase our understanding of the context within which the schemes have been implemented, so that transferability can be judged.

REA Glossary

Acronym	Description
A/C	Air conditioning
ACEEE	American Council for an Energy Efficient Economy
ADEME	Agence de l'Environnement et de la Maîtrise de l'Énergie (French Environment and Energy Management Agency)
BBNP	US Better Buildings Neighborhood Program
BET	Bureau d'étude thermique (organisation providing thermal energy design services)
BPI	Building Performance Institute (USA)
BUS	Build Up Skills (an EU-funded strategic initiative to increase low energy refurbishment skills in the construction sector)
CAPEB	Confédération de l'Artisanat et des Petites Entreprises du Bâtiment
CEE	Consortium for Energy Efficiency
CVET	Continuing Vocational Education and Training
DENA	Deutsche Energie-Agentur (German Energy Agency)
Education	Generally used to describe learning undertaken in a formal classroom-type setting
EQF	European Qualifications Framework
FETAC	Further Education and Training Courses
FFB	Fédération Française du Bâtiment
GETS	Green Energy Training Services
GPRO	Green Professional Operations and Maintenance
H2020	The European Union's Horizon 2020 funding programme
HARDI	Heating, Airconditioning & Refrigeration Distributors International
HIP	Australian Home Insulation Program
HVAC	Heating Ventilation and Air Conditioning
HVE	Higher Vocational Education
IVET	Initial Vocational Education and Training

JATC	Joint Labour-Management Apprenticeship Training Councils
LEC	Low Energy Construction
NQR	National Qualifications Register
NZEB	Nearly Zero Energy Building
OSS	One Stop Shop
REA	Rapid Evidence Assessment
Training	Generally used to describe learning undertaken in a less formal setting for example ‘on the job’.
VET	Vocational Education and Training

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Appendix B: Scheme overviews from Phase 2

This section provides information on specific schemes provided by stakeholders in their interviews and supporting reports and papers.

Better Buildings Neighbourhood Programme (USA)

Scheme name	US 'Better Buildings Neighbourhood Programme' (BBNP)
Description	Created in response to the need to drive economic activity as well as deliver energy efficiency, post the 2008/9 financial crisis. The scheme had a national level overarching structure and set of objectives, but ultimately were implemented in different ways at the state and local levels.
Geographical reach and market size	BBNP was a US Federal programme, implemented in every State.
Timescales	2010-2014
Stakeholders involved	Utility companies, financial institutions, local governments, community-based organisations
Depth of retrofit	Various, but mostly 'deep', achieving more than 15% household energy savings
Number of properties retrofitted	99,071

House2Home (Ireland)

Scheme name	House2Home (H2H), a 'One Stop Shop'
Description	The first such on the Irish market, offering free advice and a single point of contact for householders wishing to retrofit, including management of SEAI (Sustainable Energy Authority of Ireland) grant process and other grants or loans that may be available. H2H offer a free evaluation to householders with a guarantee of performance of the measures.
Geographical reach and market size	Whole of Eire
Timescales	2009 to present and still operational (but with annual funding gaps).

Scheme name	House2Home (H2H), a ‘One Stop Shop’
Stakeholders involved	SEAI
Depth of retrofit	Undertake both deep and shallow retrofits.
Number of properties retrofitted	Several hundred ‘shallow’ ie single measures completed in 1-2 days and around 150 ‘deep’ retrofits, each taking 2-3 months.

Tipperary Energy Agency (Ireland)

Scheme name	2008 to 2012 as part of Concerto project (H2020)[172] SERVE[173] SuperHomes Ireland[174] (SHI)
Description	Owner occupier deep retrofit scheme, involving insulation, air source heat pumps and a demand control ventilation system.
Geographical reach and market size	Ireland (mostly Dublin).
Timescales	SHI 2016 – ongoing.
Stakeholders involved	None directly beyond installers but influencers – see below.
Depth of retrofit	Up to 60% realised energy savings (on old, hard to treat houses). Average cost of all the homes has been 38,000 € ex VAT
Number of properties retrofitted	Around 100 a year. Limited by contractor and Government grant availability

[172] https://www.concertoplus.eu/
[173]Sustainable Energy for the Rural Environment http://servecommunity.ie/
[174] https://superhomes.ie/

Passive House (Global)

Scheme name	Passive House (Passiv Haus)
Description	The Passive House concept is the only internationally recognised, performance-based energy standard in construction. A Passivhaus is an energy-efficient building with all year-round comfort and good indoor environmental conditions without the use of significant active space heating or cooling systems. The space heat requirement is reduced by means of passive measures to the point at which there is no longer any need for a conventional space heating system; the air supply system essentially suffices to distribute the remaining space heat requirement. The EnerPHit Standard is for retrofitting properties.
Geographical reach and market size	Global Passivhaus's biggest market is in Europe, initially beginning in Germany, the concept is being developed with the EU across 33 countries. Other markets include: • North America, where the PHI has a close partnership with both US and Canadian governments. • China • Japan • South Korea • More recently PH are developing the market within the South Pacific, in collaboration with the Australian and New Zealand governments.
Timescales	1990s - ongoing
Stakeholders involved	Passivhaus works predominantly with architects, building engineers and building physicists; the people involved in the design and delivery of both new build and retrofit projects. This includes working with R&D teams within manufacturers, and engaging with intermediaries, such as local government and social housing providers. The Passiv Haus Institut (PHI) also engages with both policy makers and building users (through a PH socials programme) to educate stakeholders on better buildings and energy efficiency.
Depth of retrofit	Whole house.

Number of properties retrofitted	Data not available.

BetterHome (Denmark and Sweden)

Scheme name	BetterHome
Description	One Stop Shop launched by supply side actors (Danfoss, Grundfoss, ROCKWOOL and VELUX[175]). Mainly for single family homes built 1950-1990. Digital platform provides hassle-free route for homeowner, also simplifies process for installers. .
Geographical reach and market size	Denmark and Sweden
Timescales	Launched 2014 – ongoing
Stakeholders involved	Manufacturers (see above), banks and mortgage providers Network of 3,500 installers
Depth of retrofit	Mainly deep with spend of ~€50-70,000 and energy savings of 30-70%
Number of properties retrofitted	~2000 since 2014

Energiesprong (Global)

Scheme name	Energiesprong
Description	Energiesprong is a net zero whole house refurbishment and new build standard and funding approach. Performance is guaranteed for 40 years enabling owners to invest future energy and maintenance savings in upgrading their home. Retrofits aim to be completed within 10 days. Energiesprong works with independent market development teams, who intervene in the market by creating mass demand within collectively owned housing stocks. The mission is to create an industry in several countries, which is able to design, produce and deliver whole house retrofits with excellence across millions of houses. The aim is to drive an industry that creates better, cheaper and more desirable retrofit solutions, ensuring everyone can live in a home fit for the 21st century. Industrialisation enables higher quality and more affordable solutions, defined as one that costs no more than what the

[175] VELUX no longer involved.

Scheme name	Energiesprong
	householder would have spent before on energy and maintenance. Energiesprong originated in the Netherlands, where it began as a government-funded innovation programme to drive an improved energy efficiency standards.
Geographical reach and market size	Global While the scheme was set up in the Netherlands, operations have expanded to Germany, France, northern Italy, the UK and North America (New York state – RetrofitNY and California).
Timescales	Live
Stakeholders involved	Energiesprong team in each country Government Social housing providers Component manufacturers Construction companies Designers or architects
Depth of retrofit	Deep. Whole house retrofit.
Number of properties retrofitted / in construction / in procurement	**Netherlands:** 6,000 completed **France:** • 200 completed/under construction • 6,500 in pipeline **Germany:** • 120 completed/under construction • 11,500 in pipeline **UK:** • 85 completed/under construction • 1,000 in pipeline

Success-Families (Nordic consortium, EU)

Scheme name	Success-Families (Successful Sustainable Renovation Business for Single- Family Houses)
Description	A one stop shop to support single family households through renovation and energy retrofits. The scheme provided energy assessors to give households the retrofit options for their property and a range of service providers to install products. This included both energy efficiency and renewables.
Geographical reach and market size	Nordic consortium including Finland, Norway, Denmark and Sweden, which was part of a larger EU consortium. Was unable to provide figures on the size of the retrofit market, other than to say that the market for single family houses was large across the Nordic consortium.
Timescales	Ongoing at an EU level.
Stakeholders involved	Energy assessors and consultants, installers. Organisations focussed on single family households. Motiva – Finish government organisation that promotes energy efficiency.
Depth of retrofit	Promoted as deep retrofit, but household ultimately decided on the path they would take and over what time period.
Number of properties retrofitted	Unknown.

Home Insulation Program (Australia)

Scheme name	Home Insulation Program (HIP)
Description	The HIP was a component of the Energy Efficient Homes Package, in turn an element of the Commonwealth Government's $42 billion *Nation Building and Jobs Plan.* It had two objectives: to generate economic stimulus by supporting jobs and small business and to improve the energy efficiency of homes.
Geographical reach and market size	Australia, in each State.
Timescales	July 1st 2009 to February 19th 2010.

Stakeholders involved	Medicare Australia for program delivery.
Depth of retrofit	The scheme was designed to reimburse householders for having had ceiling insulation installed. Claims for reimbursement could be made up to $1,600 initially, later reduced to $1,200.
Number of properties retrofitted	Over 1 million Australian homes had ceiling insulation installed.

This publication is available from: www.gov.uk/government/publications/domestic-retrofit-supply-chains-international-review

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