



Domestic retrofit supply chain initiatives and business innovations: an international review

SPECIAL COLLECTION:
RETROFIT AT SCALE:
ACCELERATING
CAPABILITIES FOR
DOMESTIC BUILDING
STOCKS

RESEARCH

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ABSTRACT

A systematic review of international evidence on housing retrofit supply chains was undertaken for the UK government: a Rapid Evidence Assessment (REA) summarised the most relevant research from outside the UK; key emerging themes were examined via analysis of 10 expert interviews with European and UK stakeholders, selected for the depth and breadth of their experience in developing retrofit business models. Market development requires concerted efforts from industry and policy, including the regulation of minimum standards. Conservatism in the industry means that opportunities for retrofit will be ignored in preference for the less risky, more familiar repair, maintenance and improvement (RMI) market. Successful retrofit involves customer engagement and after-care, which is outside customary practice. Financing mechanisms are important for firms' cashflow and for customer acceptance. Skills governance needs to take account of national vocational education systems, and is more complex than simply providing a few new courses. Local partnerships are needed to mobilise and organise the supply chain, whether through local government involvement or new business models enshrining collaborative quality assurance. More formal quality assurance implies some consolidation of supply chains. All these elements must be integrated into a service package, whose overall purpose is to minimise the risks of retrofit for supply chains and customers.

POLICY RELEVANCE

A functioning, large-scale energy-efficiency retrofit market needs to have some of the attributes of the existing RMI market, with energy performance grafted on. When compared with the ideal requirements for effective policy, existing policy support is inadequate, being too short-lived, too inconsistent and too easily sidelined by market realities. Retrofit requires high-quality outcomes achieved through integrated service, but construction industry business culture is focused on inputs (not outcomes) and the service is fragmented. Policy must help deliver a cultural shift, which no country has yet succeeded in bringing about. The task may be slow as it entails coordination and change across policy, education and vocational training, and industry practices.

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KEYWORDS:

capability; construction industry; energy efficiency; innovation; retrofit; supply chain

TO CITE THIS ARTICLE:

Brocklehurst, F., Morgan, E., Greer, K., Wade, J., & Killip, G. (2021). Domestic retrofit supply chain initiatives and business innovations: an international review. *Buildings and Cities*, 2(1), pp. 533–549. DOI: <https://doi.org/10.5334/bc.95>

1. INTRODUCTION

The decarbonisation of heat is recognised as being both essential and highly challenging (CCC 2019). In its latest report on housing the UK Committee on Climate Change (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 (CCC 2019).

Firms in the supply chain for repair, maintenance and improvement (RMI) of housing can be very influential over consumer decisions, especially in privately owned homes, which make up over 80% of the stock (Owen *et al.* 2014; Wade *et al.* 2016). Even in social housing, where the client role is more professional and experienced, the social organisation of project teams can have a big impact on outcomes in terms of energy performance, workforce productivity and occupant satisfaction (Killip *et al.* 2014). Innovations of practice and process are important for good-quality outcomes, including energy performance; technological innovation alone will not be sufficient without changes in the business models and organisation of projects, firms and networks of collaborators across the entire industry (Killip 2013).

Fragmentation is widely seen as one of the most challenging attributes of construction generally (Dainty *et al.* 2007; Clarke *et al.* 2017), and is very marked in the market for housing RMI, where there is a high proportion of small and micro-businesses operating in informal networks, satisfying local market demands. Installer firms are often profit ‘satisficers’, preferring to make a steady living from familiar methods and materials, rather than seeking innovation as a means to maximise economic returns (Maby & Owen 2016). The reliable availability of products and materials is also a factor in firms’ preferences about what to specify, reinforcing the widely observed tendency for conservatism (Killip *et al.* 2020).

The UK’s Green Deal policy was intended to be transformative, but was abandoned in 2015 after only two years, its failure due to poor policy design, political dogmatism and a failure to listen (Rosenow & Eyre 2016). The subsequent Each Home Counts review (Bonfield 2016) engaged with industry stakeholders on issues of consumer advice, protection, standards and enforcement. It led directly to new occupational standards for retrofit installers and retrofit ‘coordinators’, a new job role for the mainstream RMI market. The UK government’s Department for Business, Energy and Industrial Strategy (BEIS) is now more aware of the importance of supply chains in developing a genuine market for retrofit. In 2018, BEIS commissioned a field trial of six ‘demonstrator’ projects in England, presenting supply chain innovators with funding over three years to develop local retrofit markets in different locations (BEIS 2021). In parallel, it commissioned this research to learn useful lessons from international experience in stimulating retrofit markets.

The research was carried out partly under contract to BEIS between September 2019 and April 2020. The aim was to identify the factors leading to successful retrofit supply chains outside the UK and to examine whether they are replicable in the UK market. Hence, only studies reporting on practice outside the UK were included in the review. The initial literature review was shaped by a series of research questions defined by BEIS.

The paper is structured as follows. The second section describes the two-stage methodology—literature review and follow-up stakeholder interviews; and section 3 summarises the results. The discussion in section 4 relates the findings back to the original research questions. The conclusions in section 5 highlight the lack of success internationally in developing retrofit markets, and the specific lessons for the UK government from this research.

2. METHODOLOGY

The project was structured into two phases, beginning with a Rapid Evidence Assessment (REA) in phase 1, which led to the identification of key issues to explore in expert interviews in phase 2.

2.1 PHASE 1: RAPID EVIDENCE ASSESSMENT (REA)

The methodology followed the Department for Environment, Food and Rural Affairs (Defra)/Natural Environment Research Council (NERC) guide titled *The production of quick scoping reviews and Rapid Evidence Assessments: A how to guide* (Collins et al. 2015). BEIS research questions were translated into an agreed set of REA questions. Peer-reviewed (white) literature and high-quality grey literature were searched using agreed keywords and exclusion and inclusion criteria, resulting in a manageable list of publications for detailed study and synthesis. Keywords were developed using the Population, Intervention, Comparator, and Outcome (PICO) model, and refined as the project progressed.

The peer-reviewed literature was searched using the database platforms Web of Science and Scopus. The grey literature was searched using a combination of the internet search engine Google (using identified search strings), specific searches of relevant institution websites and conference paper databases, and requests for suggested literature made to key contacts in the project team’s networks.

Sources were evaluated against the exclusion and inclusion criteria, initially by title and then by abstract. Evidence was extracted from the selected sources into standardised templates and rated for relevance and robustness using criteria which were defined for each REA question and evidence type (e.g. general, qualitative, review). The extracted evidence was then analysed to draw out preliminary findings against each of the REA questions and to identify key issues to explore further using expert interviews. (For the full REA, methodology and results, see the supplemental data online.)

2.2 PHASE 2: EXPERT INTERVIEWS

These key issues were then discussed in a series of interviews with experts, including academics and stakeholders from the buildings industries. The initial plan had been to select interviewees representing countries with well-developed supply chains that were successfully delivering home retrofit at scale. However, the phase 1 findings found no countries in this situation. Phase 2 interviewees were instead selected on the ‘information content’ of informants (Flyvberg 2006), reflecting a good geographical spread of relevant expertise. Informants were selected by approaching authors identified in phase 1 and through snowballing contacts of the authors, in order to find individuals with relevant knowledge.

The interviews were semi-structured and conducted using a topic guide that was agreed with BEIS. Relevant stakeholders were selected in consultation with BEIS; 10 interviews were held (with 11 stakeholders—Interview B had two stakeholders) (*Table 1*).

Table 1 Interviewees.

INTERVIEWEE	INTERVIEWEES’ ROLE AND BROAD EXPERIENCE	INTERVIEWEES’ BROAD GEOGRAPHICAL EXPERIENCE
A	Experienced in the new business model for retrofit	Western Europe
B	Experienced in the new business model for retrofit	Western Europe
C	Experienced academic researcher	Western Europe
D	Experienced practitioner with new business model experience	Western Europe
E	Academic researcher	Western Europe and North America
F	Experienced practitioner	Western Europe
G	Experienced researcher working on policy and demonstration projects for housing retrofit across countries	Western Europe
H	Researcher and communicator for a new business model entity	Predominant, but not exclusive, experience in Western Europe
I	Scientist in a research centre with 20 years of experience in energy efficiency	Scandinavia
J	Political scientist with experience in projects in energy-efficiency retrofit	Western Europe

Where interviewees suggested or provided additional literature that had not been identified during the REA in phase 1, this was also reviewed during this phase.

The interview transcripts and additional literature were analysed thematically in a series of discussions among the researchers in an iterative process of coding, repeated until the whole research team was satisfied with the result. The resulting set of eight thematic codes gives broad coverage of all the topics revealed to be important in the interviews. The judgement of 'importance' is based on the number of times a theme arose, the number of different interviewees for whom it was an issue, and the priority given to it by the interviewees themselves. The selected themes relate to distinct topics of interest that were mentioned by at least two interviewees, and which together cover the most important, challenging and cross-cutting issues raised. There is an inevitable element of subjectivity involved; performing the thematic analysis in this collective, iterative way helped reduce the risk of overstating the importance of any theme. Eight themes were chosen for the evidence from this second stage, and are reported in section 3.2.

The methodology is described in full in the supplemental data online.

3. RESULTS

3.1 PHASE 1: RAPID EVIDENCE ASSESSMENT (REA)

A list of all the references by REA question are given in the supplemental data online.

3.1.1 REAQ1: What is the evidence of the influence of the supply chain on the success of domestic energy efficiency retrofit?

Based on the findings of this REA, the influence of the building supply chain on the success of energy efficiency retrofit is little studied: eight relevant references were found (three peer-reviewed, five in the grey literature). All related only to domestic buildings, seven related to energy efficient/green/nearly zero-energy building (NZEB) renovation, and six also covered new build. The scarcity of research was also found in a review of retrofit 'intermediaries', mostly focused on local authorities and agencies rather than the construction supply chain (Kivimaa & Martiskainen 2018). It seems reasonable to conclude that the evidence base is indeed small, not that it was missed because the search strategy was weak.

Two qualitative studies of the experience of customers who have commissioned domestic retrofit, in the Netherlands (de Wilde 2019) and Finland (Murto *et al.* 2019), both found that the supply chain in these countries did not serve customers well: it was difficult to find impartial advice on what best to install, hard to compare quotes and customers were left uncertain of the quality of the installations.

Another review was also critical of the supply chain, although in a particular situation: a national Australian loft insulation scheme (Hawke 2010). Although in some ways the scheme was very successful (over 1 million homes had been insulated), it was stopped early because of four installer deaths and over 100 house fires linked to the installation of insulation. The speed of its implementation, lack of adequate training and poor supervision of installers were factors in its failings.

Some studies, looking at schemes in Canada and the US, found a more positive connection between the supply chain and success of domestic retrofit: Foster *et al.* (2012) and Bickel *et al.* (2016) both looked at specific examples of midstream incentives (providing the incentive to a distributor of equipment rather than the customer) for high-efficiency heating, ventilation and air-conditioning (HVAC) equipment. They found that this was a good way of engaging the supply chain and that this in turn increased the uptake of schemes.

Two broader reviews of multiple schemes both found that engaging the supply chain effectively was essential for success in the short and longer terms, but that doing this can be difficult, particularly with smaller contractors (Thorne 2003; Gillich & Mohareb 2018).

3.1.2 REAQ2: What is the evidence of how supply chains for domestic energy efficiency retrofit operate outside the UK?

There were 15 peer-reviewed 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.

There is little evidence of well-developed retrofit supply chains anywhere, but even so, there are some recurring themes: supply chains are fragmented, and this can reduce the quality of retrofits; integration at the interfaces between contractor roles is important for success but the innovation required for this is difficult; but there are actors who can be intermediaries.

Supply chain fragmentation is reported in European Union (EU)-wide studies (Boza-Kiss & Bertoldi 2018) and for specific EU countries, for instance, the Netherlands (de Wilde & Spaargen 2019), Denmark, Finland, Norway and Sweden (Mahapatra *et al.* 2013), and France (Killip *et al.* 2014). This is also true for the US (Brown *et al.* 2019) and Australia (Hawke 2010). This fragmentation leads to poor-quality retrofits (Brown *et al.* 2019; Killip *et al.* 2014). In addition, retrofits are not generally a high priority for traditional building contractors, e.g. in Sweden (Pardalis *et al.* 2019), Belgium (Cré *et al.* 2012) and France (Nösperger *et al.* 2011).

One study found that the supply chain is dominated by small and medium-sized enterprises (SMEs) and that in these businesses the competencies and resources to develop an innovative, partnership-based business model for scalability were limited (Mlecnik *et al.* 2017). 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 (e.g. Brown *et al.* 2018, 2019), and between innovations in products, practices and processes (Killip *et al.* 2014). Nonetheless, small builders can be innovative if clients allow time and money for experimentation (Mlecnik *et al.* 2019).

There are actors other than supply chain firms who can act as intermediaries, predominantly public sector organisations (Kivimaa & Martiskainen 2018).

3.1.3 REAQ3: How do members of the domestic energy efficiency retrofit supply chain upskill in different countries?

Relatively few pieces (13) of evidence were found that were relevant to this topic (from 2008 to 2019). All sources relate to energy-efficient/green/NZEB, although not all relate only to renovation (many also covered new build) and none relates only to domestic buildings.

Research on 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 (e.g. Blomsterberg 2013).
- The need to improve the skills of the existing workforce so that they can work with new, low or zero-carbon technologies and build or renovate to the high standards required (e.g. Mikkonen *et al.* 2011).
- The need to meet socio-economic requirements: to diversify the workforce (e.g. Shoemaker & Ribeiro 2018), to provide a route to skilled employment for a part of the population which struggles to find work (e.g. Foshay 2012) or to provide work in an area with high unemployment (e.g. Ferguson 2018).

Most of the evidence focuses on the training provided, but some sources cover related aspects. One looks at funding/operation (Le *et al.* 2012), one describes the training and, qualitatively, the results (Dandridge *et al.* 2010), and one details a formal evaluation of the indirect energy-efficiency impacts of four state-wide (Californian) Energy Efficiency Education and Training Programs (Opinion Dynamics Corporation *et al.* 2009). Most of the evidence is concerned with training outside full-time education, although some included that in schools, colleges or universities (e.g. Mikkonen *et al.* 2011). Most of the training is technical in nature, but some is in sales, marketing and customer service (Ferguson 2018).

The evidence, covering 19 countries, is diverse and it is not possible to summarise these meaningfully within the constraints of a paper—the results are in full in the supplemental data online. The findings of a study of 10 EU countries (Clarke *et al.* 2019) gives a flavour. Overall, continuing VET was found to be fragmented and uncoordinated, 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, policymakers and the general public, was also noted as a barrier to increasing demand for low-energy construction and related VET.

3.2 PHASE 2: EXPERT INTERVIEWS

A set of eight analytical themes was developed iteratively and collaboratively by all authors: scale and market development; culture of industry and innovation; customer engagement; finance; skills; local partnerships; risk; and quality assurance. Each is discussed below.

3.2.1 Scale and market development

Interviewees who had compared programmes across countries felt that there is a contrast between those that sought long-term market viability without subsidies and those with simplistic, ‘here today, gone tomorrow’, objectives:

There is always uptake while you are financing it, and then it [uptake] just falls off a cliff. (interviewee E)

Several stated that a sustained strategy for achieving scale requires a government-led ambition for 10 or even 20 years, with clear numerical targets. Another suggested that such an ambition is a helpful platform, but needs to be supported by a multi-year funding strategy that avoids ‘boom and bust’ periods in an annual funding cycle, which result in contractors finding it difficult to be confident in their workload:

none of those [elements of market development] happen when governments chop and change. (interviewee F)

A network of policies is needed to get the best results:

[Upper Austria] has got [...] carbon taxes that are rising every year, they have grants [...] the framework of market support and market development. The trained advisors get free training courses, there are high standards required [...] oil heating is banned from 2035, they’re doing an advertising campaign in 2020 [...]. (interviewee F)

Interviewees knowledgeable about new business models noted that even they remain small scale in the context of the overall challenge within each country. One initiative does, however, have a mission to scale their approach to more markets, to create an industry which is able to design, produce and deliver whole-house retrofits with excellence across millions of houses; they believe this will require active international engagement with policymakers and developers. The business model targets collectively owned stock because that is preferable to brokering individual householder deals at scale.

In summary, the expert views gathered here suggest that the development of markets at scale requires a combination of efforts from policy and industry. Regulated minimum standards (or bans on certain technologies, such as oil heating) provide an impetus for innovation and a stable context for investment. The public sector also has a role to play in paying for training and aspects of quality assurance. The private sector’s role is in designing and implementing business models that deliver quality and profitability.

3.2.2 Culture of industry and innovation

Many interviewees described a ‘too busy’ culture amongst supply chain actors, which meant it was difficult for retrofit programmes to attract their interest. For some contractors new-build projects

are more attractive anyway because renovation and retrofit involves the ‘hassle factor’ of dealing with resident homeowners.

Interviewees described difficulties working with the predominantly microscale businesses in the sector, because the self-reliant culture and working practices of these smallest firms do not readily fit with business models based on coordination and collaboration.

Despite these difficulties, experiences seemed to show that supply chain interest can be built if there is long-term support and a consistent policy context:

[the contractors] were too busy to attend [local roundtable meetings] at first, but then they started to see that there was a volume of money here that would drive them to attend [...] that the government was serious about it and it was going to be there for the next three years [...]. (interviewee E)

Another mentioned the culture of competition between advocates of particular technical solutions, which can be confusing for householders:

the battle between different technologies to be seen as ‘the answer’ for the consumer. (interviewee B)

There are new business models, such as *Energiesprong*, operating in retrofit that set out to innovate by disrupting the usual supply chain by working directly with manufacturers to reduce costs of measures through brokerage opportunities. Interviewees with knowledge of these described their new approaches, and importance of coordinating different stakeholders:

We are encouraging demand for better products. We have developers and manufacturers approaching [us] to be included in our component certification scheme. (interviewee H)

We want to broker the market [...] working with social housing providers, government and regulators. [...] We are showing a different path—and asking the market to meet that. (interviewee A)

Several aspects of industry culture are identified as being problematic for the development of innovations, including for retrofit. The overlap between energy efficiency retrofit and traditional RMI work has been presented as one of opportunity, with potential synergies and market opportunities. But the reality is that traditional RMI work is familiar and the market for it is mature, whereas retrofit carries risks (real and perceived) and requires supply chain actors to learn new ways of doing things, including deploying unfamiliar materials and technologies in new ways. There is therefore a strong impetus to reduce risk and hassle by simply ignoring the market potential of retrofit and continuing to offer conventional RMI services. Some kind of cultural change will be needed at a significant scale if the market opportunities are to be realised in any more than tiny numbers operating in niche markets.

3.2.3 Customer engagement

Interviewees gave many examples of how householders were best engaged in the possible benefits of retrofit and throughout the process of getting it done. The use of an advisor/concierge was thought by a number of interviewees to be vital:

the energy concierge [...] would be familiar with the technical and non-technical sides of it [...] so a single face, hand-holding through the whole process. (interviewee E)

This type of role can also 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’. (interviewee B)

Some also used local taskforces as ambassadors to create awareness, drive interest and stimulate demand amongst potential householders, and even undertook demonstrator projects in homes of local opinion-leaders. One, from a new business model enterprise, stated two key success drivers of their scheme credibility:

Doing installations in high profile environmentally related individuals' homes. [...] Support from press and [...] politicians [...] having visited retrofitted houses. (interviewee F)

Alongside this, examples were also given where government schemes had been well advertised and had raised householder awareness and interest, as had schemes from local government and financial institutions.

Most interviewees mentioned that householders are motivated by having beautiful, healthy and comfortable homes, with environmental benefits and cost savings of secondary importance:

[we're] selling comfort [...] or health benefits [...] or improved air quality. (interviewee H)

what drives retrofit in homes is comfort. They want to know the investment will pay itself back at some stage [...] and they are driven by environmental reasons as well. (interviewee F)

Another theme mentioned by several interviewees is the importance of post-installation householder follow up and 'training':

show them [...] the insulation and heating systems [...] a full training day to go through the system. (interviewee D)

From this evidence the customer journey for retrofit is an important aspect of market development because customer satisfaction depends on a meeting of needs, expectations and symbolic meanings bound up not just in the energy-related works, but also in the concept of 'home'. Delivering a successful retrofit involves concerted efforts of engagement, education and a degree of after-care which are often absent in conventional industry practices.

3.2.4 Finance

Interviewees discussed needs for (government) funding and also access to attractive finance. Some noted that the more sophisticated programmes vary the design of funding over time, depending on feedbacks, the availability of other funding streams and the stage of development of the retrofit journey within the country or region:

There are programmes in the US where they would deliberately not fund something because they knew the market was going to get that anyway [...] it would look good on their books, but it wouldn't be serving the overall purpose of what they were trying to do. (interviewee E)

fluctuating the rebates [...] to keep the demand steady, [...] you have a lot of seasonal effects with this work, and they tracked that [...] to make sure that there is steady demand [...] and let the market grow around that certainty. (interviewee E)

The timing and continuity of timetable were also critical:

there is a gap from October to January each year [...] from a contracting point of view, from a stakeholders' point of view, it was a nightmare. (interviewee D)

Bank loans were seen as a key finance option for households, especially during periods of low interest rates when banks see providing 'green' finance as a key new business opportunity. However, when energy prices are low, long payback periods become a barrier. It was noted that homeowners could benefit from better finance (lower mortgage rates) and subsidies when undertaking known, branded schemes, such as Passivhaus.

However, in some countries finance institutions may not have as much impact as first appears:

The banks are very clever with loans, they say that they have pledged 5 million, but they [...] haven't used very much of it. (interviewee D)

Finally, there was a common theme of householders' cash flow affecting their ability to take part in a scheme. Some new businesses have models that enable them to take the upfront risk:

We pay up front and then use the grants so that we are reimbursed [...] the funding needs to discount to the customer up front, rather than them having to wait for the funding to come. (interviewee D)

In summary, finance is important for retrofit, as it is for any major capital expenditure. The detailed design and operation of financing mechanisms is important for cashflow and customer acceptance, as well as for the additional workload of supply chain actors. Cumbersome form-filling or unattractive forms of financing may be enough to undermine the delivery of projects.

3.2.5 Skills

Many interviewees note that there are too few skilled and capable individuals in the retrofit supply chain and training is critical to tackle this problem. This is particularly the case in places and times when builders are fully employed anyway.

There are a number of interlinked reasons given for the shortages of skills. First, there is often little incentive or capacity for self-employed builders to invest their time in skill development:

construction training has been almost destroyed [...] this kind of really rather crazy belief in an employer-based system [...] where the employers don't have the capacity to train. (interviewee C)

Second, there is both a lack of access and willingness to incur the costs of training, which includes time away from income-earning work:

the problem is that someone needs to pay for it. I mean it's time that they could have spent on work. (interviewee J)

Third, the responsibility for coordinating in-work training is devolved to the individual trainee in the UK, in contrast with some other European countries:

in many countries [...] work placements are found for the trainee, rather than the trainee having to find an employer to get work experience [...] that can be an absolute nightmare in this country (UK). (interviewee C)

Fourth, the nature of the training is often very narrowly based, developing specific skills only and lacking a breadth of what is required for retrofit, including problem-solving across disciplines:

the Irish scheme is good is because it's looking much broader at problems of coordination [...] and problem solving [...] building] theoretical knowledge-based elements into practical application. (interviewee C)

Some suggested that learning new things takes time, regardless of previous industry experience:

this is not going to be solved over the next couple of years. [...] Existing tradespeople might take a couple of years to get used to doing things in a certain way [...] and then you think you would be better at getting young people to take it on from the start. (interviewee D)

Informal learning among peers can also have value:

the lads, every failure they see they put on the WhatsApp group [...] every time they have a question [...] they put it on the WhatsApp group. [...] Yeah, little things like that [...] that's literally how you build the capacity. (interviewee F)

Many countries' programme funders have required a published standard of training for installers. In addition, several interviewees also gave examples where marketing and finance training had given valuable extra benefits to supply chain actors, for instance helping them be more effective salespeople.

One interviewee from a new business model entity stated that their training was focused on capacity-building for design architects and building engineers, for design and build quality, and only to a limited extent for installation and installers.

In summary, the expert interviews raised questions about the quality, quantity, content and audience for skills training. The context and institutions for vocational training in different countries provide very different starting points, and the international comparison therefore needs to be treated with caution. A key unknown that remains is the degree to which informal and *ad hoc* learning tools (e.g. a WhatsApp group among on-site workers) can substitute for formal learning through college courses and apprenticeships. The accuracy and effectiveness of these different initiatives cannot be assumed to be equal. The construction industry needs to address skills training more thoroughly, including:

- Who needs to know what?
- How and where can those skills be acquired?
- What systems of governance are needed for vocational education to be taken up at scale and relevant skills to be used in the workplace?

3.2.6 Local partnerships

Many interviewees stressed the importance of tailoring locally led partnerships, processes and solutions, under the platform of national policies:

all retrofit happens at a local level with local people and local houses. And it's why it's such a challenge. (interviewee F)

Many also described active roles of local authorities in leading programmes, becoming intermediaries, collaborating with local supply chain actors and raising awareness amongst householders:

local policy actors are more important with regards to [...] implementation in the field and in target areas. If they are engaged [...] usually things start to happen. (interviewee G)

One described the importance of running regular roundtable meetings for local contractors together:

they realised [...] they had access to this much bigger pool of projects. They knew if they didn't do a good job, they wouldn't be invited back. So that created trust with the supply chain [...]. (interviewee E)

In summary, local partnerships are necessary because retrofit is by its nature a locally delivered service, which means context is important. Any policy or business initiatives that aim to increase investment in energy-efficiency retrofit need to recognise and work with this fact. Given that retrofit is a very immature market, local authorities often have an important role in convening networks and brokering, as well as being important intermediaries in customer engagement and building demand for retrofit. Partnerships between firms are also observed, reflecting the

multidisciplinary nature of retrofit work. Some business models are structured to provide training and quality assurance through sharing risks; poor performance is policed because the reputational risk is also shared in a cooperative structure.

3.2.7 Risk

Different risks were experienced by householders, supply chain companies and programme designers, all of which may present barriers to increased retrofit activity.

For supply chains the conversion rate of initial interest into actual project delivery is a key risk to manage:

you want to subsidise the assessment, a little bit, to get people in the door, but then you've got to actually convert that. So, they very scientifically experimented with that [...]. (interviewee E)

For supply chain actors, the scale and reputation of a programme can reduce their risks in taking part:

[small contractors] find [...] the scheme reassuring and like to have connections with these big, well-respected firms. (interviewee B)

Installers like getting well-specified projects and a high conversion rate of leads to projects:

The high conversion rate means that installers like [...] the service, as there is a very high chance that they will lead to work. (interviewee B)

Good coordination can reduce the risk to both other contractors and the householder:

if you have a One Stop Shop you have a clearer contract [...] a single point of contact that handles all of this, so this doesn't land on the building owner. (interviewee J)

Interviewees involved in developing and implementing new business models explained that they put considerable effort into engaging with the whole chain to build trust and transparency:

We engage with companies—would they be interested in working with us. [...] Then repeat, repeat, repeat. Then talk deals. [...] This is an art—not a science. (interviewee A)

For householders the risk increases with the scale of the project:

homeowners do perceive a much higher risk from deep renovation than from phased retrofit. (interviewee G)

Some schemes take the specific risk of supply chain failures away from the consumer:

We've had contractors go bust [...] and we've looked after the homeowner. We've had contractors do very poor work and we have sent in remedial contractors and fixed it for them. (interviewee F)

Some new business models included guaranteed future energy performance to householders. Others focus on risk management as one dimension of quality assurance:

[our] focus is quality assurance at a property level, and in turn reducing consumer risk and building trust with stakeholders. (interviewee H)

In summary, there are risks for both firms and customers in taking part in retrofit activities. Some risks are related to retrofit being unfamiliar, linked to the immature state of the market. Others (such as firms going bust) may be more generally present in the industry. It is a feature of retrofit programmes that the coordinators have taken some responsibility for both kinds: the risks may be increased but so is the willingness to remedy problems when they materialise.

3.2.8 Quality assurance

Interviewees stressed the importance of retrofit work being done to the right level of quality, with a quality assurance actor on the ground:

So where it was the programme [that employed the energy advisor] they would use the energy advisor to do quality assurance checks on the buildings. (interviewee E)

One interviewee's experience was that it is easier to ensure consistent quality throughout the supply chain when interventions are being done at scale:

If there are groups of homeowners who decide to renovate together [...] then everybody agrees that quality should be somehow incorporated in [the] process. If it's just single family then [quality assurance] will never be mentioned in the contract. (interviewee G)

Several mentioned that funder insistence on final assessed certifications is an effective quality assurance mechanism.

Several described a process of dialogue and engagement with the householders over time as a means of ensuring sustained project quality:

At a number of touch points, short customer satisfaction measurements are recorded. At the end of a project, a deeper interview is carried out so that the programme can learn from the customer's experience and feed this into wider programme learning. (interviewee B)

Quality assurance may be addressed by more or less formal means, from contractual conditions to details of business model design. Larger projects tend towards greater formality—of contracts, of service expectations and of professional credentials. The process of aggregating retrofit demand into larger projects seems to do more than simply increase financial viability: it also formalises the nature of the service being offered, which in turn lends itself to more formal processes of quality assurance.

4. DISCUSSION

The starting assumptions and lessons learned across the two phases of this research underline the need for policy attention on the organisation of retrofit markets. The original questions set by BEIS proved unanswerable, because they enshrined a number of erroneous assumptions about how retrofit markets operate. Specifically, REAQ1 framed the 'success' of retrofit in terms of influence from the supply chain, whereas the evidence showed that the influence of supply chains is inextricably bound with other factors, including client demand and the framing of policy. There was no definition of 'success' in this context; in fact, the real finding was that no country or informant had found a way of achieving successful retrofit at any significant scale. Similarly, REAQs 2 and 3 were predicated on assumptions about the market which were not borne out in the evidence. The reality is that market development is heavily contingent on policy and contextual factors, as shown by the findings of the phase 2 interviews.

Most of the interviewees had experience of developing retrofit offers and business models, operating in the private sector. There was a wide recognition that public sector support is needed to make retrofit work. Financial support is needed because of the high opportunity costs of creating work, and the generally low volumes of work created while markets are immature. The opportunity costs relate to client engagement and education, as well as convening collaborative partnerships of delivery firms. Trust between clients and installers often needs careful nurturing, as does trust within and among teams of firms working together on projects and longer term programmes. Local networks of firms also often rely on the convening power of local government partners.

A common complaint from interviewees is the inconsistent and short-lived nature of retrofit policy. The time and skill invested in building relationships and developing market capacity is wasted when policy support is suddenly cut short.

A key problem is that a living can be made from repair work without taking account of energy retrofit. This reflects an important market failure: the innovative and novel approach may be supported by programmes or high-level policy targets, but there is no compulsion for firms to take part or even take notice. Given the construction sector's generally weak record in innovation and its culture of risk-aversion, the fact that firms choose to avoid getting involved in retrofit should come as no surprise.

Retrofit remains an important plank of climate policy around the world, but the evidence of this review is that retrofit initiatives have all struggled to achieve delivery at any significant scale. Nimble and creative pioneers continue to engage with retrofit in different contexts, but they are relatively very small in number. There is an overall sense that these pioneers are swimming against a strong tide of disinterest from the vast majority of RMI firms, and that the various forms of policy support, financial incentives and new business models have not been strong enough to turn that tide.

Retrofit policy not only needs to be more consistent, but it also needs to be more effective.

5. CONCLUSIONS

No country has managed to make retrofit mainstream: it remains the preserve of enthusiastic practitioners, programme designers and customers. Retrofit is an immature market compared with the dominant sector of repair, maintenance and improvement (RMI). This means that the vast majority of firms and customers continue to carry out projects with little or no attention being paid to climate or energy policy. The potential has been identified, the high-level policy targets are in place, but delivery continues to stutter.

When compared with the ideal requirements for effective policy, as expressed in the literature and by the interviewees, existing policy support is inadequate, being too short-lived, too inconsistent and too easily sidelined by market realities. The dominant market for housing RMI offers opportunities for integrating retrofit works at the same time, but they are not being taken at any significant scale.

A sobering lesson from this research is that it initially aimed to answer questions that proved to be unanswerable. These questions were based on erroneous assumptions about how the RMI and retrofit markets operate. Academic journal papers and authoritative reports from high-profile bodies such as the Committee on Climate Change (CCC) contain information that challenges these assumptions. But the initial design of this research exercise suggests that such information is not reaching policymakers effectively; or if it is, then it does not translate into action in any logical or predictable way. There is therefore an urgent need for more collaboration between those producing the insight and those using it to understand what is needed to translate it into optimal policy design.

The findings of the literature review and interviews show that retrofit is complex and messy; its delivery is fragmented and contingent. And yet exactly the same can be said of the RMI market, which reaches into every home and delivers billions of pounds worth of work every year. The dilemma for policy is that the desired endpoint (a functioning, large-scale retrofit market) needs to have some of the attributes of RMI, but with the new purpose (energy performance) somehow grafted on. This is proving to be a deceptively difficult thing to achieve. Retrofit requires an industry committed to high-quality outcomes achieved through integrated service. But the reality is that the industry is focused on inputs (not outcomes), and the service is characterised by fragmentation (not integration).

This study shows that no country has succeeded in bringing about the shift, scoring instead only relatively small and short-lived programmes of activity. There is surely a role for policy in bringing about that cultural shift, but the task will inevitably be slow and messy. In the face of urgent climate targets, it may sound contradictory to argue for slow change, but the alternative seems to be something quick and ineffective. And each ineffective initiative only takes precious time and causes further delay.

The authors thank all those interviewed for this study for their time and the insights they provided.

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COMPETING INTERESTS

The authors have no competing interests to declare.

ETHICAL CONSENT

A consent form was sent to interviewees which had to be completed before the interview took place. This asked whether the stakeholder agreed to take part in the research, whether they gave permission for the interview to be recorded and whether they were prepared to be identified in the published report by name and/or organisation. The consent form and interviewers also made it clear that stakeholders were free not to answer any question that they would prefer not to.

FUNDING

The initial research (the Rapid Evidence Assessment (REA) and stakeholder interviews) were undertaken as part of a project for the UK Department of Business, Energy & Industrial Strategy, 'International Review of Domestic Retrofit Supply Chains', from September 2019 to April 2020. Additional analysis for this paper was partly supported by the UK Research and Innovation (grant number EP/R035288/1) (Centre for Research into Energy Demand Solutions).

SUPPLEMENTAL DATA

Supplemental data for this article describing the methodology for the Rapid Evidence Assessment (REA) and the stakeholder interviews, and the full findings of the REA can be accessed at: <https://doi.org/10.5334/bc.95.s1>

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TO CITE THIS ARTICLE:

Brocklehurst, F., Morgan, E., Greer, K., Wade, J., & Killip, G. (2021). Domestic retrofit supply chain initiatives and business innovations: an international review. *Buildings and Cities*, 2(1), pp. 533–549. DOI: <https://doi.org/10.5334/bc.95>

Submitted: 11 January 2021

Accepted: 26 May 2021

Published: 25 June 2021

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