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Emerging models of environmentally sustainable enterprise: a comparative study of low-energy housing retrofit organisations in the UK and France

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ABSTRACT

Objectives: This paper examines emerging models that are being adopted by organisations engaged in the low carbon transition, with a particular focus on the role played by social enterprises. It presents a case-based comparison of recent efforts by industry actors in the housing retrofit supply chain to deliver low-energy retrofits (or refurbishments) of existing housing stocks in the UK and France.

Prior Work: The study adopts a multi-disciplinary approach which makes connections between three broad strands of research: (1); energy policy, with a focus on energy efficiency in buildings (e.g. Fawcett and Mayne 2012); (2) social and sustainable enterprise (e.g. Blundel *et al*. 2013, Gibbs and O'Neill 2012); (3) socio-technical transitions (e.g. Geels and Kemp 2006; Smith 2007, Killip 2013).

Approach: The issues are examined through a comparative study of the low-energy housing retrofit policy environment and of current organisational structures and practices in the building industries of the UK and France. Industry responses to recent policy signals are explored in case materials that are based around reviews of published evidence and a series of semi-structured interviews with designers and contractors who have direct experience of innovative, low-energy refurbishment projects in each country.

Results: The case study evidence suggest that while the two countries have comparable long-term policy goals for CO_2 emissions reduction, there are important organisational differences displayed in the more immediate initiatives being undertaken by industry actors involved in delivering retrofitting of the housing stock. The discussion section indicates possible explanations for these differences and highlights issues requiring further investigation.

Implications: The transition towards a more environmental sustainable residential housing depends largely on social, as opposed to technological, innovation. Policy-makers need to address specific organisational constraints, including the longstanding fragmentation evident in this part of the UK building industry. The cases suggest that there is considerable scope for reconfiguring traditional networks and for giving greater emphasis to collaborative arrangements involving private sector firms, social and community based enterprise.

Value: The study provides new empirical insights into the organisational dimensions of an important sustainability transition. It also makes a contribution to theoretical development by combining insights from several distinct disciplines, and by applying concepts from energy research, organisational studies, social entrepreneurship and socio-technical transitions to recent development in the UK and French building industries. It also identifies several implications for future research policy and practice.

Keywords: *building industry; retrofitting; socio-technical transition; SME; social enterprise; innovation*

1. Introduction: the policy context

The built environment must undergo dramatic changes to meet climate change targets. The World Business Council for Sustainable Development (2009) calls for a worldwide building sector energy reduction of 77% below projected 2050 levels. In both Britain and France, the residential sector is the largest consumer of energy and the main emitter of CO_2. Both countries have set themselves ambitious long-term CO_2 emissions reduction targets, and both have identified the improvement of existing housing stocks through renovation as an important part of a wider climate change mitigation strategy (HM Government 2008; French Government 2009, 2010). In France, the Environment Roundtable ('*Grenelle de l'environnement*') and the inter-departmental '*Programme Interministériel de Recherche et d'Expérimentation sur l'énergie dans le Bâtiment*' (PREBAT) both highlight housing refurbishment as the top priority in achieving European and Kyoto Directives. In Britain, the recently launched 'Green Deal' is designed to help homes and businesses make energy improvements by deferring upfront costs. Killip (2008) has estimated that transforming the entire UK housing stock by 2050 will require 500,000 refurbishments of older, inefficient properties every year. The sheer scale of these transformations demands radical change in both technology and work practices.

Each house has a unique history that may give rise to a variety of technical issues (e.g. the quality of the original construction, the impact of previous refurbishments and extensions, the current condition of windows, wiring, brickwork etc.). Actual levels of domestic energy use are also dependent on the distinctive characteristics and behaviours of its occupants at any particular point in time (e.g. number of occupants, life stage, pattern of work and leisure activity). For these reasons, it would be necessary to optimise a whole suite of available technical and social strategies for each existing dwelling in order to yield the best carbon emission reductions. This represents a tremendous, yet largely unacknowledged challenge for a highly fragmented building construction and maintenance industry. In both the UK and France, housing refurbishment is largely the preserve of small and medium-sized enterprises (SMEs), which include general builders, specialist builders (e.g. roofing contractors), plumbers, heating engineers, electricians, architects, design engineers, project managers, and building control inspectors. These groups are often considered to be 'intermediaries' in the technology adoption process, and as such are expected to provide low carbon refurbishment if their clients demand it. There is an urgent need for new and existing actors in the refurbishment industry to deliver consistent, high quality output, not simply in the design of new retrofit projects but also during the installation process in ongoing maintenance and 'after-sales'. There is considerable research and anecdotal evidence that high quality service delivery is essential to the success of low-carbon refurbishment projects, particularly in the areas of insulation, thermal bridging and air-tightness (Bell and Lowe 2000). However, it is also evident that intermediary groups have established habits, working practices, and ways of thinking about problems that influence their interest in promoting, and their capacity to provide, low carbon refurbishment services.

This paper draws on initial findings of a three-year research project, 'Building Expertise,' which involves researchers at the Environmental Change Institute, University of Oxford and the European energy efficiency research centre (ECLEER) of Electricité de France (EdF), which explores the responses of contractors and design professionals to the policy-led drive for energy demand reduction and reduced CO_2 emissions through the refurbishment of existing housing stocks. As part of a further collaboration with the Department for Public Leadership and Social Enterprise at The Open University, we are examining the organisational dimensions of this issue, with a particular focus on the role of social enterprises and other forms of entrepreneurial actor in promoting social innovations that are capable of meeting the retrofitting challenge. The main research questions are:

- What kinds of business model and organisational and inter-organisational arrangement are being adopted in order to deliver low carbon retrofitting or refurbishment of the domestic housing stock?
- How are these innovations seeking to transform traditional networks in this industry sector?
- What are the implications of these developments for practitioners, policy-makers and researchers with an interest in of low-carbon refurbishment?

The paper is structured as follows. It begins with a brief account of the project's overall research approach, the subset of methods used in this paper, and the socio-technical transitions literature which has been used as a theoretical framework for the discussion section of this paper[1]. The central section is a comparative case study, with two country-specific sections that summarise the policy context for low energy housing retrofitting activity in France and the UK. Three case examples are presented, which highlight some of the more noteworthy industry responses encountered during our recent fieldwork. This is followed by a section on 'emerging themes', in which we reflect on topics that have been raised by several interviewees and highlight some striking contrasts between our observations in these two countries. The concluding discussion relates these provisional findings to the wider literature on socio-technical transitions and considers the implications for researchers and policy-makers.

2. Research approach and theoretical framing

The present paper is framed around an emerging literature on social and sustainable enterprise (e.g. Underwood *et al*. 2012a, 2012b), and the socio-technical transitions approach (e.g. Geels 2008, Hoogma *et al*. 2005). It also sits within a broader socio-technical systems ('STS') tradition (e.g. Hughes 1986, Bijker *et al.* 1987). STS posits that all technologies have both a behavioural component and an artefactual component, leading to the observation that innovation and change involves the co-evolution of new technologies and new social practices. We have used an international comparison as a means of examining national assumptions and the ways in which the policy debate on retrofitting is framed (Anderson 1996). The term 'behaviour' in much of the energy-related literature refers to the social practices of building occupants, but in this research we focus instead on the working practices of those who make a living from the repair, maintenance and improvement (RMI) of the housing stock. The artefacts involved in retrofitting include the pre-existing buildings and a variety of products and technologies that can be installed to improve their energy efficiency and reduce their CO_2 emissions (e.g. solid wall insulation, draught proofing, double and triple glazed windows, solar hot water panels, ground source heat pumps, condensing boilers etc.). Product innovations should not be discounted or ignored in the discussion of how to make low-energy housing refurbishment mainstream, but the focus should not rest solely on new technologies. Indeed, the fact that advanced refurbishments can already be achieved using existing technology suggests that the task of retrofitting housing stocks should be considered a 'market breakthrough' problem, rather than a 'technical' one (Unruh 2002). It is also worth considering what is meant by 'innovation' in this context. In many cases, innovation is used as a synonym for 'new technology', but here it is taken to include novelty across three domains: **products** (technology), **practices** (customary ways of doing specific tasks) and **processes** (the organisation of all the tasks involved in a project), the latter two generally being identified as social innovation[2]. Another important distinction is provided by Barrett *et al*. (2007), who argue that innovation in the context of project-based service industries means, 'not what is new *per se*, but what is new to the firm'. This understanding of 'innovation' helps explain why even well-established retrofit products can continue to have only a small market share because they are not yet incorporated into the mainstream practices and processes of the RMI industry. Therefore, if we wish to increase

[1] The 'Building Expertise' research project from which this paper is drawn uses a complementary theoretical lens, derived from Andrew Abbott's 'system theory of professions' (Abbott 1988). Through this frame, its sees the task of housing renovation as a new 'jurisdiction' or domain of workplace activity, which is contested by different professional groups seeking to claim it as their own. This notion of contested jurisdictions allows for the evolution of working practices within the building industry to be investigated in a way that fits within a broader framework guided by the socio-technical systems (STS) literature. The systems of professions approach and its potential application to retrofitting activity is elaborated further in Janda and Killip (2013).

[2] For a recent review of the multi-faceted term 'social innovation', see Nicholls and Murdock (2012: 1-32). Our interpretation encompasses both the 'process' and 'outcome' strands of this literature (ibid. 13, Pol and Ville 2009), and will be elaborated upon as this working paper is further developed.

adoption of technologies (old and new), it helps to understand both the working practices of those we are calling upon to do the installation work and the ways in which they are organised[3].

The paper connects with several strands of the socio-technical transitions literature, which can be summarised briefly. Firstly, the focus on changes in the low energy refurbishment industry can be seen as part of a wider quasi-evolutionary and multi-level process in which a socio-technical 'regime' (i.e. the established set of actors engaged in this activity) undergoes a transition, with a disruption of its established patterns normally being generated by pressures that are conceptualised as being exerted from 'above' and 'below' (Rip and Kemp 1998, Geels 2002). The area 'below' the level of the regime may be occupied by one or more innovative 'niches' in which new experiments can be conducted. Secondly, it relates to the literature on strategic niche management and grassroots innovation (e.g. Smith 2007, Seyfeng and Smith 2007). In the case of low energy housing, much of the impetus for change came from pioneering communities of self-builders, whose practical experimentation grew out of the environmental activism and student protest movements of the early 1970s[4]. The area 'above' the regime is constituted by changes in the wider socio-economic 'landscape' (Geels 2002), which in this instance include governmental targets on carbon emissions and wider concerns over global warming. Thirdly, the policy-oriented nature of the issues suggests a link to the more purposive 'transitions management' literature (e.g. Loorbach and Rotmans 2010).

Research methods

Our research is exploratory in nature and does not claim to be comprehensive or representative. We deliberately seek to understand innovative practices as a means of prompting new topics for debate, not as a means of finding ready-made solutions. The fact that innovators can be found in this field is not an indication that the mainstream is about to change. However, the innovators have to operate in the same policy and cultural context as mainstream incumbents, and their innovations can provide insights for industry strategy and policy-making. We use a comparative case study method for the empirical section; this method can be particularly appropriate when the research focuses on contemporary rather than historical phenomena, and when the researchers cannot control the events in question (Yin 1984). Due to financial limitations and the difficulty of reaching the target population, our project has addressed only a small number of innovations and innovators in each country. However we have increased the efficacy of these cases by making observations at different levels of analysis (King *et al*. 1994), and by using multiple methods (Putnam 1993). The wider project has so far collected data from a variety of (sometimes overlapping) sources: 30 interviewees (20 in UK; 10 in France); numerous site visits, discussions and meetings in both countries to help us understand innovative industry initiatives; literature reviews and ongoing monitoring of policy developments to help us understand the context in which industry initiatives are framed; a small number of interactions with householders living in renovated homes to help us understand the (perceived) benefits and problems from the end-user's point of view. In this paper, we focus on a subset of our data which comprise one case of innovative practice in France and two cases from the UK. Case 1 (France), a new co-operative venture, was explored through four recorded interviews, several discussions with two founding entrepreneurs, and numerous meetings and discussions with staff from EdF Commerce, the organisation that had provided start-up capital and ongoing technical and managerial assistance. Case 2 (UK) was identified during the course of the research. Oxford researchers attended two dissemination conferences where the organisation concerned (a social landlord) presented the results of its recent retrofitting work. We also followed up with organisational contacts to set up interviews with the trades and workers; retrospective interviews with 14 employees were completed during 2012.

[3] We have also reflected on the role played by entrepreneurial agency in sustainability transitions (Blundel and Monaghan 2009) and on the ways in which intra- and inter-organisational networks can contribute to innovative activities of this kind: Gibbs and O'Neill's (2012) empirical work on green building networks in the UK has several parallels with the case studies presented in this paper.

[4] For example, an interesting and pioneering example of handmade, owner-built eco-houses in the Northern Rivers region of New South Wales grew up in the wake of the Aquarius festival of 1974. See: 'Not Quite Square: The story of Northern Rivers architecture'. Sample images available at: www.timhixsonphotography.com.au/exhibitions/index.html

Case 3 (UK), also a new co-operative, is based on an in-depth interview with one of its founders, who was already known to members of the Oxford research team as an industry innovator, and on the observation of two industry working groups.

The case study: low energy retrofitting in France and the UK

FRANCE

Policy context

The long-term strategic policy framework for France is provided by the 'environment roundtable' (*Grenelle de l'Environnement*), which calls for a fourfold reduction in energy consumption by 2050 across the entire economy. One significant enabling policy is consistently identified by interviewees: the zero interest 'eco' loan (*éco-prêt à taux zero*, abbreviated as PTZ). The introduction of the PTZ in 2009 was largely a response to the limited improvements being made to the thermal envelopes of buildings through the system of income tax credits for sustainable development (*crédits d'impôt développement durable*, abbreviated as CIDD), introduced in 2005. In the early years of the CIDD the eligibility criteria for supported measures did not change in response to the different speed of change in different markets, which meant that nearly half of credits went towards window replacements in 2007 (85% of windows on the market being eligible). In contrast, only 5% of CIDD expenditure contributed to wall and roof insulation. The rules were changed in 2007, effectively tightening the standards for eligibility of windows under CIDD. The PTZ has a different structure. To qualify for the loan there are two routes: one based on packages of measures and one based on a design standard. To qualify for the loan via the package-based route two or more work packages must be undertaken from a prescribed list:

- High-performance roof insulation
- High-performance wall insulation
- High-performance windows and doors
- Installation or replacement of a system for space heating or hot water
- Installation of thermal renewable energy technologies for space heating
- Installation of thermal renewable energy technologies for water heating

Alternatively, the loan can be used to pay for improvements achieving a design standard for the whole home, with the required standard post-works being based on a modelled assessment of energy demand pre-works (Table 1**: Qualifying design standards for whole-home approaches under the zero interest loan scheme**).

Table 1: Qualifying design standards for whole-home approaches under the zero interest loan scheme

Modelled energy demand pre-works, kWh/m^2.year (primary energy)	*Qualifying standard (modelled) post-works to receive the loan, kWh/m^2.year (primary energy)*
OVER 180	150
UNDER 180	80

Under the PTZ scheme 150,000 loans had been made by the end of 2010 (against a target of 200,000) but numbers have fallen away since the rules were changed, effectively disallowing the use of both CIDD and PTZ on the same project. France has a feed-in tariff (FIT) for microgeneration technologies, such as solar photovoltaics. But the tariff arrangements are not linked to policies and programmes designed to improve energy efficiency.

Industry practices and innovations

In France there are two accreditation schemes for skilled practitioners, each supported by a different trade association: the '*éco-artisan*' scheme, supported by the *Confédération de l'Artisanat et des Petites Entreprises du Bâtiment* (CAPEB); and 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).

Case 1: The 'Builder-User' Co-operative

This venture is a new company with a co-operative governance structure that offers guaranteed performance contracts to clients for its refurbishment services. This innovative business model is still being developed at the time of writing, so evidence on its longer-term effectiveness remains limited. However, it provides an interesting insight into the potential for social and organisational innovation in this sector. The contractors doing the refurbishment works are all members of the co-operative, as are the clients. This governance structure is designed to maintain a balance of voices in the ongoing development of the organisation, both operationally and strategically.

The new cooperative plans to start with 15 renovations in its first year, expanding to 35 in the second year, so as to allow time for learning and making any necessary changes to the systems before extending its client base. The design process for the retrofits is based around a central technical function. Bespoke modelling software is used to generate a predicted energy performance for each property, based on the design standard of the renovation works and a detailed list of energy-using behaviours (i.e. occupancy, internal temperatures, washing and cooking habits, etc.). These parameters – both technical and behavioural – are used to create an energy performance standard, which underpins the contract between the client member (i.e. the resident) and the co-operative (i.e. renovation service provider). If subsequent energy consumption figures fail to meet these performance expectations, the co-operative will carry out a review of contractual obligations on both sides. If the outcome of the review is that the residents are honouring their contracted behaviours, the contracting firms are deemed to be at fault and will take responsibility, either for rectifying the renovation work or for reimbursing the client for any additional costs. In cases where the contracted behaviours are not being honoured by the occupant (e.g. if another family member or friend has come to live in the home since the contract was drawn up), then the new occupancy pattern is modelled, and a new contract is drawn up. These organisational arrangements are underpinned by technology in the form of energy use monitoring systems, which operate on a constant basis (i.e. sensors are used to collect and update temperature, humidity and CO_2 data for each property). This monitoring system allows the co-operative to identify any atypical energy use patterns or other issues that might require remedial action. For example, a sudden drop in CO_2 concentrations in the indoor air would suggest that a window has been opened; if this continues over an extended period, the monitoring system can send an automatic text message or email to the client, asking them to check.

Start-up finance for this co-operative was supplied by the French energy company EdF. However, the co-operative governance structure ensures that strategic and operational control shared equally between the contractor and client members, rather than being concentrated in the hands of one or more large shareholders. For contractors, co-operative membership is conditional on key their personnel being trained under the '*Eco-Artisan*' programme. The contractors also operate their own 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 where necessary. Ultimately, the co-operative has a right to expel any member that consistently fails to comply with the commitments of its contractors' charter. However, consistent with its collaborative ethos, the preferred course of action would be for the co-operative to raise the quality of the members' work through encouragement and training.

THE UNITED KINGDOM

Policy context

The UK is in the process of moving away from a system based solely on energy company obligations ('Carbon Emissions Reduction Target' in their 2008-2012 form) which delivered high numbers of low cost individual energy saving measures. The new system retains an element of the (renamed) Energy Company Obligation (ECO), but in addition there is the new 'Green Deal' (GD), which is a financing method, by which the duty to repay capital is attached to the property, rather than to a person. A key feature of the GD is the 'golden rule', by which the (modelled) energy savings achieved over 25 years must be equal to (or greater than) the costs of investment.

The UK's feed-in tariff (FIT) for small-scale renewable energy technologies was revised in April 2012 to make an explicit link between energy efficiency and renewable energy for the first time. The revised tariff is now higher for installations in homes which are rated D or better on the Energy Performance Certificate.. Homes with a lower rating can still get the FIT, but at a lower rate per kWh generated (Department for Energy and Climate Change 2012).

Industry practices and innovations

If we follow the logic that the kinds of innovation needed in this service market are related to practices and processes as well as products; and if we accept that the important measure of 'innovation' in this context is that it is new to the firm, not necessarily 'new' per se, then an important first step is to understand what current practices and processes are. The UK construction industry as a whole (not just the residential RMI sub-sector) has published its own reviews in the last twenty years, led by recognised leaders – first Sir Michael Latham (Latham 1994), then Sir John Egan (Egan 1998, 2002), and most recently Andrew Wolstenholme (Wolstenholme *et al*. 2009). The second Egan review characterised the construction process as 'a series of sequential and largely separate operations undertaken by individual designers, constructors and suppliers who have no stake in the long term success of the product and no commitment to it' (Egan 2002: 13). The most recent report summarised the impact of the earlier reviews as 'skin deep', with many of the issues highlighted by Egan still very much in evidence (Wolstenholme *et al*. 2009: 4). The following case studies of innovative practices and processes should be read in the light of this rather bleak assessment of where the industry currently stands.

Case 2: The Innovative Housing Association

This case involved a social landlord (a large housing association with 16,000 properties), which had a plan to undertake a series of 30 low-carbon retrofits of near-identical houses in southern England. The work was supported by European Regional Development Fund (ERDF) financing. As part of the funding agreement, the social landlord participated in public conferences to disseminate lessons learned from their retrofit process. The housing association had its own in-house repair and maintenance team, many of whom had been employed by the organisation for many years. These tradespeople therefore had a lot of shared history. Fourteen of the team members involved in this work were interviewed, in order to build up a picture of their different accounts and experiences.

As might be expected, the work became faster and more efficient as the team grew in experience. This learning process was facilitated by an early decision to renovate an initial four properties as a kind of test-case. The aim was to learn from mistakes as much as possible, with the added advantage that it would be easier to manage the temporary re-housing of tenants from the other properties if a small number of homes were ready to be occupied before new works got under way. Early on, the site manager was found to have insufficient experience and organisational skills for the project, so the task of site management was passed to a more experienced colleague who was a qualified architect. A site office was set up on-site so that problems could be reported and resolved quickly. A three-person site management team was found to be very effective, with three areas of responsibility: supervision of the team of tradespeople; advocacy of the needs of the landlord client in terms of budget, specification and quality control; and engagement with tenants to ensure good communication between residents and the on-site team. Interviews were conducted with the site supervisor and the client advocate, but it was not possible to interview the tenant liaison officer.

A system of financial incentives was introduced by the site supervisor to promote efficient working, based on a bonus scheme, which was to be shared by all operatives on a pro rata basis. Thus, wherever a task was unfinished, those without enough work to do at that point in the project in their own area of skill and expertise were expected to help out. In this way, carpenters might find themselves doing work for plasterers, or vice versa. In fact, the task of external wall insulation was the one where this system of teamwork was most noticed, both because of the quantity of work involved and because of the hard physical nature of rendering outside walls in cold weather. The practice of 'multi-skilling' was remarked on by several members of the team as being unusual and innovative. Many also commented that it was only workable because these individuals had a long history of working together in the housing association, which meant that they knew one another, trusted each other's skills and knew where to deploy each person in the team in order to play to their individual strengths[5]. The process of learning over the course of doing work on over 30 houses led to significant improvements in labour productivity. After the first two renovations had been completed, the whole project was running over-budget: but by the end, significant budget savings were being made, leading to a healthy level of bonuses for the team. The demands of the low-carbon renovation itself led to unforeseen practical problems. The most striking of these was the negative impacts on the health of two plasterers, whose elbows became painful through prolonged periods applying render to wall insulation. A special mechanical spraying device could have been hired but the decision was taken to apply the render by hand in order to save money. Other problems emerged too, which required 'on-the-job' solutions. For example, where residents had satellite television dishes on the outside of their home, a means had to be found to re-attach the dish through 150mm of insulation without compromising the weather-proof properties of the render and with minimal loss in performance through thermal bridging. This type of *ad-hoc* challenge resulted in frequent 'skip meetings' where the workforce downed tools in order to talk through how best to resolve issues as they arose. The organisation of the team was characterised by good communication, shared responsibility and a collective focus on finding practical solutions.

Case 3: The Contractor's Brokering Co-operative

This idea for this venture originated with one of the UK's 'retrofitterati'[6], a group of industry experts who frequently participate in events on energy retrofits and eco-refurbishment. It represents the latest in a number of process innovations initiated by this individual. Many SMEs in the construction industry have, through their trade associations, identified low-carbon renovation as an economic opportunity (Killip 2008). However, the requirements of the new GD initiative (i.e. accreditation of installers, certification of works, form-filling for finance and monitoring purposes) are widely perceived to have created too large a bureaucratic burden for smaller firms. This has resulted in a widely-held view in the industry that the GD administrative function will be taken over by larger corporations, who can fulfil the government's administrative requirements at scale while sub-contracting out the practical work to SMEs. The drawback of this arrangement, from the perspective of the SME, is that profit margins are likely to be eroded by the corporate 'middle man'. These concerns over the GD have prompted industry working groups to engage in an extensive series of debates about an alternative brokering scheme. The process was led by the founder of one start-up company, which had managed several home renovation projects, carried out stock surveys for social landlords, devised and conducted training courses on eco-renovation, and been active in policy debates. The new brokerage scheme has been designed to allow the SMEs to pool their resources in a co-operative structure. This should enable them to fulfil the role of the 'middle-man' collectively, through a shared 'back office' function, and thereby to secure a greater share of the profits from GD projects.

Much of the discussion around the detail of this proposed scheme has focused on finding a fair and effective means of allowing firms flexibility in how they respond to requests for work ('leads'). This

[5] Where two people had worked for a long time in a team, they likened the relationship to a marriage, managing the division of labour quite meticulously so that each one did the tasks which they enjoyed and were best at, leaving the rest to their job partner to complete.

[6] We are indebted to another interviewee for this novel term.

debate has boiled down to designing a scheme that gives its members three choices when they first receive a lead: to take the work on entirely by themselves; to do part of the work themselves but engage other firms to carry out certain specialist tasks; to pass the lead on to the brokering service in return for a finder's fee, thereby giving other members the opportunity to carry out the work.
The model for this new venture is a co-operative owned by small companies, designed to allow for flexible and efficient sharing of business opportunities. The co-operative allows SMEs to compete for more ambitious projects by providing a pool of specialist firms to call upon and technical support services for energy-related issues. The co-operative's technical service department also provides an independent energy assessment service to customers, which is not tied to any particular installer organisation. The idea is to give the small businesses who are already talking to homeowners about refurbishment projects the support needed to 'upsell' those projects to include energy efficiency measures and low-carbon technology options.

The co-operative structure is open to other types of organisation besides construction, who are not themselves able to provide the renovation service, but who are well placed to find property owners who want the service on offer (eg local authorities, community groups). In the proposed model such organisations could then pass on these potential customers in return for a finder's fee. All co-operative members are expected to use shared branding and consistent information to help build consumer trust. In addition to providing 'back office' functions to satisfy the administrative demands of the GD, the co-operative provides two key technical services:

- An assessment methodology to show people (householders) their options
- Training courses for the supply chain

The courses cover 'everything that a building tradesperson needs to understand about how to upgrade buildings – the design and the installation'. This is a set of skills which is not yet the preserve of any recognised profession, but it matches quite closely what the World Business Council for Sustainable Development have termed the 'integrator' role (WBCSD 2009). According to this interviewee the key attributes for this job are:

- Ability to control budgets
- Good understanding of design
- Very wide but shallow knowledge (with recourse to specialist assistance when necessary)
- Good people management skills ('getting people to do stuff that they don't really want to do necessarily')

While an experienced project manager can operate effectively on low-carbon projects without being an energy expert (so long as more expert advice is available), 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 questioned further about the essential characteristics of a low-carbon refurbishment project manager the answer was: 'it's about managing the interfaces'. And in this context 'interfaces' means both efficient organisation of resources (e.g. communicating with other contractors to make best use of scaffolding) and being a responsible professional (e.g. acting in ways that will help other trades who follow you on site, or communicating with those who go before so that the hand-over is efficient).

In contrast with the French co-operative (Case 1), this brokerage scheme stops short of offering energy performance guarantees, based on the judgement that contractors would not feel willing to expose themselves to the risks of failure. Instead, the model contracts promise 'best endeavours' on behalf of the contractors, but not actual results in terms of energy performance. The need for a project manager can easily lead to the assumption that this will entail additional cost to the project, but this interviewee put forward the opposite argument, based on several years' experience working on these projects and being involved in training tradespeople: '[having a project manager] makes the job easier and cheaper … we need these project managers on site to make these things happen. On every job I

think they would pay for themselves'. More fundamental to the question is the tiny pool of currently available talent: 'my worry is I don't think there's more than about 20 people in the country who can do that project management job well'. This industry innovation came about as a direct result of the new Green Deal policy being announced, but the process of cause and effect between the new policy and industry innovation is far from straight-forward. The high interest rate on Green Deal finance (not yet finalised at the time of writing, but likely to be around 6-7%) has been a regular source of comment and concern. This interviewee was quite sanguine about that, however, and described the new policy's effect in terms of being a 'wake-up' call to the SME construction sector: 'I actually think [the brokering scheme] will do more work outside the Green Deal than inside […] but the Green Deal is the current panic that will get everybody joined up. […] in other words most of the homeowners who [use the brokering scheme] won't need the Green Deal finance. I think they just want good contractors who understand eco stuff […] they just want a good supply chain. They want an assessment done.'

Some emerging themes

Here we draw out some of the themes that have recurred throughout the research process, and which seem to have an important role to play in shifting low-carbon housing renovation from its current niches into the mainstream. These issues also challenge much conventional thinking in policy and industry circles around the necessary changes required for a transition of the RMI regime. In this paper we concentrate on four themes that are particularly relevant to the research questions[7].

Interfaces

Chan and Dainty (2007) argue that 'the interface between new and traditional skills is extremely crucial in refurbishment and repair work'. When that refurbishment work has energy- and carbon-related goals, the importance of interfaces takes on a new technical dimension. It is therefore worth defining what the term 'interface' means in relation to low-carbon home refurbishment. Three types of interfaces can be identified in the cases presented.

- **Physical boundary interfaces** (i.e. physical joins between one part of a building and the next such as the edges between floors and walls or walls and windows).
- **System interfaces** (i.e. design and operational issues, such as the compatibility of heating technologies, control systems, heating demand and user practices in manipulating these new systems)
- **Process interfaces** (i.e. between the roles and responsibilities of different tradespeople working on a given project).

Each of these can have a vital role in ensuring that the retrofit achieves its goals. For example, at the process interface, it is essential that an electrician or plumber both understands the principles of insulation and airtightness and applies that understanding when routing cables and pipes in and around the thermal envelope of a building.

The organisation of work

Low-carbon refurbishment represents a profound challenge for industry capacity to deliver, and can perhaps be summarised in terms of integration, communication and risk management. Contractor roles are typically fragmented, each person seeking to minimise their own time on the job and their own exposure to risk. A contractor will tackle a given task with a focus on minimising their own time spent on it, regardless of the knock-on consequences for another contractor working on the same building afterwards. Overcoming this fragmentation and lack of concern for the 'whole' is not easy, as it goes against some very deeply ingrained practices. Where there have been calls for the industry to

[7] These themes have a particular bearing on organisational and inter-organisational aspects of the RMI industry. The other four themes are elaborated in companion papers, including the ECEE 2013 conference paper: tensions between technical and market potential; low-carbon refurbishment as 'up-selling'; vocational education and training; and the costs and benefits of professionalisation.

change its culture, this is one of the key areas of concern. This is also an issue in the mainstream industry but due to the technical factors involved, it has become especially important in relation to low-energy and low-carbon retrofitting. Two models have been seen to be effective to overcome these issues: the multi-skilled team based on shared tasks, shared risks, and shared problem-solving (Case 2); and the involvement of an effective 'integrator' who can manage on-site teams and provide an link between the physical work being carried out, the technical demands of the energy targets in the original design, and interactions with the client (Cases 1, 2 and 3). These two models are not mutually exclusive, and the need for flexibility across the varied RMI market may mean that some combination of both approaches will be necessary, depending on the circumstances of each project.
Another organisational innovation observed in this research is in the creation of 'back offices' to provide common administrative and technical support services. The need for such services is partly brought about by the requirements of policy initiatives (e.g. for training and accreditation, and in order to secure financial incentives), but that is not the only motivation. Practitioners with prior experience of the technical demands of doing low-carbon refurbishment have recognised the need for a cost-effective model that can deliver of specialist technical assistance for site managers when it is needed, something that is particularly evident in Case 3.

Intermediary roles

Here we use the term 'intermediary' to refer to a person or organisation facilitating understanding and communication between clients and contractors. Cases 1 and 3 provide two different approaches to bridging this divide. Where there is a project manager playing the 'integrator' role, that person may also be able to guide the client in their decision-making, in which case the integrator plays both roles and no extra intermediary is needed. However, in many cases a third party is found to be helpful in guiding the process. It may be true of innovation generally (not just low-carbon refurbishment innovations), but the personal journey that a client takes from disinterest or ignorance through to committed investor is complex and varied from case to case. The presence of a trusted person to accompany that journey is helpful. In the case of landlords, it helps to think of this as a two-stage process, with both the landlord and residents requiring some assistance. 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. The independent intermediary role is not essential, however, as there are also cases where a client has bypassed the need for an independent intermediary by acquiring (or already having) the knowledge and skills required. Even so, the burden of taking on such a role in addition to the role of project client can create its own problems, essentially because the duality of roles causes stress for the person concerned, and because the power relations become confused for other actors in the project if the client is also playing a role in the professional team.

Boundaries of responsibility

If, as has been argued, the prevailing culture in the refurbishment industry is to avoid risk and avoid taking more than a minimum of responsibility, then the call for greater integration raises the question of where the boundaries exist (or should exist) between different areas of responsibility. Such boundaries seem to exist at several levels simultaneously: between individual contractors and the tasks that each has to perform; between a putative integrator/project manager and the project team; and between the team of contractors and their clients. There has long been a debate about how to reconcile the need for physical interventions in buildings with the need also for behaviour change by occupants. This boundary of responsibility has always appeared difficult to resolve. It is too early to tell whether the French model with guaranteed energy performance contracting (Case 1) will work in the residential sector; or whether the British model of brokering with the promise of 'best endeavours' (Case 3) can make enough of a difference, when so much of energy consumption relates to the choices and practices of building occupants. Tackling these problems at multiple levels is an intrinsic difficulty of the task of achieving genuine reductions in energy consumption and CO_2 emissions from housing stock.

Concluding discussion: implications for research, policy and practice

At a technical level, the focus on advanced performance standards and whole-home approaches has led to a shift in emphasis in energy efficiency policy debates, moving away from a sole reliance on specialist insulation installers, and including many more of the different trades involved in the general RMI sub-sector of the construction industry. This shift in emphasis has created a new challenge to those engaged in researching domestic energy use and broader sustainability issues. The task of integrating energy-related works into a fragmented retrofitting market requires that expertise in energy efficiency is combined with a greater understanding of housing refurbishment as a complex socio-technical system. Cost has long been considered a barrier to greater energy efficiency, based on cost-benefit analysis of capital outlay on energy-saving interventions versus operational energy cost savings. However, while cost is clearly an important factor, it is not the only one. A recurrent and over-arching theme emerging from our discussions with innovators in the field of low-carbon refurbishment has been the need to ensure *quality* in future retrofitting activities. In this context, 'quality' refers to several related domains, most notably: quality of *design*, quality of *physical work*, and quality of *communication* between different parties. There is a tacit agreement amongst the retrofitting innovators that all of these areas need to be improved simultaneously, and that this task is very difficult due to the prevailing cultural and structural fragmentation of the industry.

The requirement for better integration exists at several levels also exists simultaneously at several different levels. It is needed at the *interfaces* between products and buildings elements; between the traditionally separate *roles* played by contractors; between the *effects* of physical interventions to buildings and the supposed behavioural *response* of occupants; and between *innovations* among the three Ps – products, practices and processes. There is also a higher-level need for better communication and integration between policy, practice and research. This is perhaps best exemplified by the need for feedback mechanisms to allow the monitoring from one project to inform the development of the next. Some innovators have taken steps to build such feedback mechanisms into their own practices, but these lessons are not being coordinated in any systematic way that might help accelerate the diffusion of new practices across the industry more generally.

A range of policy instruments has been developed to promote low carbon transitions, including the retrofitting of residential housing stock. For example, in Canada, financial incentives have been used to promote entrepreneurial activity in this area by SMEs (Burch *et al*. 2011, Natural Resources Canada 2011). While this paper does not attempt to draw conclusions regarding the most appropriate policy mix in this industry sector, it does point to some issues that merit particular attention. It has long been recognised that policy intervention to promote sustainability transitions requires a holistic approach rather than the use of isolated policy instruments (Elzen *et al*. 2004; Hoogma *et al*. 2005); they are more likely to be promoted though the application of evidence-based and context-sensitive combinations, which may encompass regulation, economic and market-based instruments, and capacity building (Blundel *et al*. 2012). Our evidence suggests that an important pre-requisite for further progress will be for these niche actors to develop new inter-organisational innovation networks and collaborative arrangements, along with appropriate support structures and capacity building[8].

We have examined three contrasting approaches to delivering low energy refurbishment projects in the domestic housing sector. Each can be viewed, in transitions terms, as an innovative niche that seeks to challenge constraints imposed by the dominant RMI regime. In each case, the success of their retrofitting innovations depends on changes in complex pattern of inter-organisational relationships, which may include small independent building contractors, larger construction and supplier companies, various forms of social and community-based enterprise, landlords, tenants, owner-occupants and environmental activists. One of the key challenges for policy-makers and researchers is to gain a better understanding of the dynamics of these emerging networks, and the ways that they can best achieve the goal of achieving radical reductions in carbon emissions from the

[8] The importance of mobilising network connections is also evident in two recent studies of environmental innovation and entrepreneurship: Gibbs and O'Neill (2012), Kishna *et al*. (2012).

domestic housing stock. There is evidence from the transitions literature to suggest that public agencies and other organisations can use network management methods and participatory methods to facilitate interaction between stakeholders, which can promote constructive debates and negotiations. A recent example of this is the so-called 'roof transition', where the chief executive of Esha, a Netherlands-based manufacturer of bituminous products, began to formulate a strategy to transform roofs into products that could contribute to sustainable energy, efficiency and CO2 reductions within 10–15 years. Recognising that a fundamental change would be necessary to realise this vision, the CEO established an innovative niche called the 'Earth Recovery Open Platform' (EROP). This involved a range of stakeholders, 'municipalities, local water boards, large manufacturers of roofing products, knowledge institutes, companies where implementation was envisaged, environmental NGOs, architects, urban planners and energy companies' (Loorbach and Rotmans 2010: 240). Transition researchers have suggested that multi-actor networks of this kind can be more effective if they are aligned with horizontal, sector-specific policy coordination (e.g. transport, energy, housing, economy, spatial planning) (Geels *et al*. 2008: 13). However, network governance remains at the heart of the issue, and there are many ways in which a poorly-configured network could become ineffective. Though low energy retrofitting may not necessarily be enacted as a 'grassroots' innovation, Smith and Seyfeng's (2007) conclusions on this type of sustainability initiative can be usefully re-applied to the cases outlined in this study:

'If an innovation agenda is brought to the grassroots, a number of governance issues are raised. Grassroots innovations will become boundary objects, interpreted differently by networks of actors encountering one another's interests and commitments around the niche. Government departments have their own objectives; technology developers have a different modus operandi to grassroots idealists; ecopreneurs seek commercialisation, moving innovations from social economy to market economy; and academics bring their own agendas. Through niche engagement, and associated social learning, the positions and commitments of some actors will alter.' (Seyfeng and Smith 2007: 598).

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