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ApRemodel: A Study of Non-Technical Innovation in Multi-Occupancy Sustainable Retrofit Housing Projects

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Abstract:
The ApRemodel project is a study of multi-occupancy retrofit in the Finnish context. As part of the study a research project was commissioned to identify and compare innovative practice with regards to non-technical issues being addressed in retrofit projects being undertaken in the UK housing sector. Given that the examples were required to address a multi-occupancy scenario all of these cases come from the UK social housing sector, where the majority of multi-occupancy retrofit is being undertaken. Here we outline the cases that were reviewed, the innovations that were identified within them and the main initial findings.

Keywords:
Retrofit, case studies, social housing, innovation

1 Introduction

The ApRemodel Project (Apartment Remodel) is a research project funded by the Finnish research council, Tekes. The project is concerned with analysing current retrofit practices within Finland. As part of the project, which is mainly concerned with large-scale retrofit, an exploratory review was sought on the current innovation within the delivery of retrofit within the UK housing market. Additionally, as it was felt that the Finnish context was well served by technical innovation, the research team, led by VTT, identified that they were chiefly concerned with non-technical innovations that addressed the wider nature of retrofit covering issues such as process, people and finance. The inter-disciplinary nature of the retrofit problem is well identified within the literature (Oreszczyn and Lowe 2010, Lomas 2010). What is apparent, from the approaches being adopted by industry, is that the effective implementation of retrofit reflects this view. Models such as the Community Green Deal (Urbed 2010) or FutureFit conducted by Affinity Sutton, one of the cases within this review, show that the implementation of new technology to improve the energy efficiency of a property is only part of the story. Successful technical innovations are supported by innovations that cover issues such as resident engagement, process innovations, management innovations with regards to evaluating, modelling and measuring the performance of stock, and financial models, all have a role to play in the effective delivery of retrofit programmes. Some of the cases identified were not construction projects per se, but could be seen as enablers to support the wider goal of reducing carbon emissions from improved properties, or encouraging the adoption of new technologies.

Most of the case studies came from the social housing sector. This was driven by a number of factors. Firstly, the ability to undertake multi-occupancy retrofit has generally been limited to the social housing sector due to issues such as the locus of decision-making and the ability to access funds either internally or through grant arrangements such as the Communities Energy Savings Programme (CESP). Secondly, the social housing sector has a number of active communities of practice (Brown and Duguid 1991) dealing with retrofit, such as the Housing Forum or the National Federation of Housing, which create vehicles for knowledge sharing and make information publicly available.

The case studies were analysed through the lens of innovation. While innovation is often identified as something that is new to an organisation (Sexton and Barrett 2003), the research team looked at innovation within the context of the sector. Projects were identified as hosting innovative approaches if they were seen as new in the context of the the wider sector. The 18 case studies discussed here are the first stage of the study, which will be concluded with 5 detailed case studies selected by the Finnish research partners.

2 Literature Review

2.1 Retrofit

Retrofit of the existing housing stock is a vital component in addressing energy policy issues for the UK domestic sector (Kelly 2009, Roberts 2008, Mansfield 2009). While new build, particularly in the social housing sector, has been subject to increasingly stringent regulation, through the Building Regulations (ODPM 2006) and, more specifically, the Code for Sustainable Homes (CLG 2009), there is recognition that this will impact only a small part of the current housing stock, having only a minimal impact on overall energy use for the domestic sector. The existing UK housing stock is replaced at less than 1% per annum (HM Government 2010, Kelly 2009, Ravetz 2008), so in order to reduce energy consumption and associated carbon emissions the current wisdom is that the existing stock must be brought up to higher energy performance standards (Mansfield 2009).

Retrofitting the existing housing stock presents a large scale and complex engineering problem (Kelly 2009). However, it is can also be seen as being applied within a socio-technical system; one which has both physical and human elements. This wider perspective of the issue enables the identification of the scope and scale of the problem and indicates that it covers many issues from the regulatory and policy domains, through technical and informational issues, to people issues, each driving what can be seen on the surface as a technical problem (Geels 2005). Considering domestic energy use from a systems perspective, where the supply side and demand side are linked as a whole (Government Office of Science 2008, Swan et al. 2010), is a useful perspective to effectively understand and address the problem.

Social housing has been identified as a test bed for the development of the sustainable retrofit market (HM Government 2010). The sustainable retrofit market can be viewed as emerging, and so specific activity by Government may be required to effectively upscale the market (van Sandick and Oostra 2010) to a point where it may be acceptable to owner-occupiers or private landlords, who make up the larger proportion of the housing market. Social housing has the benefits of access to professionals who may make more informed decisions, more effectively project manage and have an existing programme of maintenance and refurbishment of their properties (Jenkins 2010).

2.2 Socio-Technical Systems

Socio-technical systems and innovation have been aligned by Frank Geels in his analysis of 3 large-scale socio-technical systems; shipping, cars and aeroplanes (Geels 2005). The purpose is to place innovation within the wider context of system factors, an analysis that could be aligned with Lesseure's (et al. 2004) antecedents of innovation.

Socio-technical systems were identified by the Tavistock group, emerging as an analytical response to the problems within the mining industry (Trist and Bamforth 1951, Emery 1993, Trist 1981). At the core is the proposition that many systems are a combination of physical and non-physical artefacts and the human context (Geels 2005) and that change was dependent on the complex interactions between these elements. Socio-technical analysis can be considered at different levels of scale, from small work groups (Trist and Bamforth 1951), right the way up to large scale national systems (Geels 2005, Verbong and Geels 2007, Geels and Schot 2007). Geels defines large-scale socio-technical systems as displaying the following characteristics;

> *" At the level of societal functions, a range of elements are linked together to achieve functionality, for example, technology, regulation, user practices and markets, cultural meaning, infrastructure, maintenance networks and productions systems."* (Geels 2005, 1)

In many ways, when looking at the domestic energy system and retrofit innovation in the wider context, all of these perspectives are necessary. Innovation is viewed as the lowest level, with new ideas entering a socio-technical domain of artefacts, rules and actors.

2.3 Innovation

Fundamentally, innovation is about change. Van der Ven identified innovation as;

> *"…the development and implementation of new ideas by people who over time engage in transactions with others within an institutional order' (Van de Ven et al. 1989, 590)"*

Much of the innovation literature focuses around the appearance of new technologies, albeit much of this is a starting point for a wider analysis; new paradigms of technology at large-scale (Kuhn 1964), or new products and services (Henderson and Clark 1990). Within the construction management literature, this concept was extended by Sexton and Barrett (2003), stating that the innovation should improve overall performance. This pragmatic approach considers that not only something new is happening, but also it is adopted (Edwards et al. 2004) and generates an improvement for the organisation. Gann (2003) takes a more expansive stance, which in the context of the retrofit problem could be considered to be more appropriate.

> *"But innovation is not solely about competition, market development and economic growth. Issues of customer choice, social and environmental sustainability and quality of life are equally important. This is particularly the case in the production and use of the built environment, which provides much of the fixed capital infrastructure required by modern society." (Gann 2003, 553)*

This perspective moves the conception of innovation away from models that focus on products or processes within individual organisations (Ettlie et al 1984, Dewar and Dutton 1986, Edwards et al. 2004), where much of the initial perspectives on innovation were formed, to that of a societal perspective with a "triple bottom line" view of sustainable development. Given the nature of the domestic energy use problem, this high level view could be considered the most useful starting point for our thinking around innovation and retrofit. Retrofit is one solution to the wider problems of climate change, fuel poverty and energy security (DTI 2006); consideration of how retrofit connects with other contingent factors, leading to related innovation outside the boundary of the problem is worth considering (Lesseure 2004).

3 Research Methodology

The objective of the research was exploratory, with a case study approach (Yin 2003) identified by the team in VTT. The research team were asked to concentrate on non-technical innovations. This did not preclude cases where there were technical elements, but a wider focus was required, addressing all issues of demand side reduction. The other factor that the research team were asked to address was multi-occupancy projects. The view of the team was that any innovation or group of innovations should be potentially applicable within a multi-occupancy environment. Another issue that multi-occupancy projects raises is the fact that this generally limits the search for projects within the social housing sector, where virtually all of the multi-occupancy residential sustainable retrofit has been undertaken.

Having outlined the search parameters a number of regional and national networks were contacted. The Housing Forum is a membership organisation that includes social housing providers, contractors, consultants and policy/ advisory members and this provided a large number of potential contacts. In addition, contacts through the National Federation of Housing, Retrofit NorthWest, the Low Carbon Economic Area and a number of identified retrofit professionals were asked to identify projects that they deemed as fitting the criteria. This was supported by an Internet search using the search terms; "retrofit housing", "sustainable refurbishment housing", "energy refurbishment housing". This approach led to multiple leads for the same projects and it was felt that a saturation point was reached when no additional qualifying projects were being identified. This initial search provided 31 projects that were then followed up by the team.

The next stage was to identify in more detail whether the cases fitted the criteria for the ApRemodel project. These were; innovative, multi-occupancy, and with a mainly non-technical focus. As we have outlined above, the definition of innovation is often viewed as something that is new to the organisation. However, in this case the team identified that the innovation context should be widened to the sector as a whole, considering current new and best practice within the sector. A researcher called the identified contact and asked them to describe their project. This identified the key perspective of the project. However, anecdotal work by the team had identified that individuals often explained their projects in a limited way or from a very particular perspective. Additionally, at the time of research retrofit communities of practice were only just starting to form within the social housing market, which made it difficult for individuals to identify what might be viewed as innovative to other organisations. To counter these issues a series of follow up questions were asked to identify the process of retrofit implementation. This approach allowed the contact to potentially identify additional activities within the projects that may be identified as innovations. This filtering approach reduced the final number of cases to 18.

After the selection process, the case studies were undertaken in more detail. A case study protocol was developed to collect the data. An outline of the data categories is shown in table 1.

Table 1 – Outline Case Study Protocol

<table>
<tr><td colspan="6">Contact:</td></tr>
<tr><td colspan="5">Summary
Summary of the project and the key innovations. It was noted in the initial data collection that many of the projects exhibited more than one innovation and in many cases these were interdependent. The innovations were initially categorised by;

People, process, technology, finance
Broad phase of application</td><td>Images of project</td></tr>
<tr><td></td><td></td><td>Pre-construction</td><td>In construction</td><td>In use</td><td>Key innovation</td></tr>
<tr><td>€</td><td>Finance</td><td></td><td></td><td></td><td>A – Main innovation</td></tr>
<tr><td></td><td>Technology</td><td>A</td><td></td><td></td><td>B – Secondary Innovation</td></tr>
<tr><td></td><td>Process</td><td></td><td></td><td>B</td><td>C – Tertiary Innovation</td></tr>
<tr><td></td><td>People</td><td></td><td>C</td><td></td><td></td></tr>
<tr><td colspan="5" rowspan="3">Innovation A -

Description of innovation</td><td>Drivers
Key drivers of innovations</td></tr>
<tr><td>Barriers
Key barriers to innovations</td></tr>
<tr><td>Benefits
Key benefits of the innovations</td></tr>
</table>

Each project was identified as having one or more innovations. These were categorised across two main dimensions. Firstly, what type of innovation, broadly categorised across 4 dimensions: finance dealing with models around funding, pricing or incentives; technology dealing with physical interventions on properties or systems within them; process dealing with innovations around delivery process; and people innovations where engagement or support activities with residents were undertaken. The second categorisation was based around the broad project process stages; pre-construction, construction, post-construction.

After the protocol was developed a more detailed desk top study was undertaken to identify all relevant publicly available material for the cases. This was slotted into the protocol to ensure that any interviews undertaken were as time efficient as possible. Interviews were undertaken to gather any missing information, and review the published information if required. When the short case was complete, it was sent to the contact for verification and any highlighted changes made.

The cross-case analysis was undertaken by tabulating the cases across the two main dimensions; stage and innovation type. This allowed elements of the cases to be compared and cross-case issues to be highlighted, as discussed in section 4. In addition to these types innovations were also categorised by two innovation types. Geels' socio-technical approach gives us a context in which innovation occurs. The lowest level of the model proposed by Geels is that of niche innovations, which will occur predominately in the infrastructure, production and technical regimes. These innovations were categorised across two dimensions. The first was the nature of the innovation itself; product, process, position, and paradigm (Francis and Bessant, 2005)

- Product – a new product or physical artefact
- Process – a new process
- Positioning – a change in context for a product or process
- Paradigm – a change in business model

The second dimension is the level of "disruption" the innovation creates within existing structures, with high levels of disruption suggesting more radical innovations. Henderson and Clark (1990) provide a model that describes innovation in this context. The model determines whether core concepts, or the linkages between them, are either reinforced or disrupted as a consequence of a specific innovation.

- Incremental innovation – these are the minor product or process improvements that do not overturn the regimes structure of artefacts or rules.
- Architectural innovation – this may be where products or processes are combined in new ways. The overall concept is not changed, but the way elements of the products link together with other innovations is overturned.
- Modular innovation – a core concept may be overturned for a specific element of the system, performing a particular modular function in a new way, but the overall system is not overturned.

- Radical innovation – radical innovation is, as the title suggests, an overturning of both core concepts and structures that link technical and rule elements of the socio-technical regime.

The results of the cross case analysis are discussed below.

4 Findings and Discussion

4.1 ApRemodel Stage 1 Cases

The cases that were selected for the first stage of the study are shown in table 2. In total, 40 different innovations were investigated from the 18 case studies.

Table 2 – List of ApRemodel stage 1 Cases

Number	Title	Brief Description of Main Innovations
1	EcoPod at Chartist House	The EcoPod was an off-site manufactured heating system incorporating gas boilers and solar thermal. This was also supported by a Building Management System. Resident engagement was also well supported through both the design of the installation process and relationship management.
2	WHISCERS	WHISCERS is a scanning system design to support the off-site manufacture of internal wall insulation with precision cutting, reducing the amount of time required to install, and reducing waste.
3	Sheffield Road Biomass, Barnsley	Barnsley has had a long commitment to the use of biomass. While biomass itself is not innovative, Barnsley Council has built an integrated infrastructure to support the local production and delivery of biomass fuel.
4	Gentoo, Pay as You Save	The pilot Pay as You Save Programme, conducted by Gentoo, served as a forerunner for the Green Deal, using energy savings gained by retrofit to finance the capital costs of the improvement programme.
5	South Wight Housing Association, Chale	A retrofit programme, which incorporated long term monitoring activity, was supported through the development of community champions, local residents who were trained to support the rest of the community through the retrofit process.
6	WattBox	This technology was applied in a number of the Retrofit for the Future projects funded by the Technology Strategy Board. It is a self-learning heating and hot water control

		supported by sensors, designed to support users meet their needs in the most energy efficient way.
7	Worthing Homes, Relish	Worthing Homes conducted a range of interventions to evaluate both behavioural and technical interventions. This looked to build an approach that would maximise the wider retrofit programme.
8	Salix Homes, Salford Barracks	The Salford Barracks project was an early example of the use of the CESP funding to undertake large-scale retrofit. This also included engagement and post-installation evaluation with residents and the use of the Social Return on Investment Model to evaluate the outcomes of the project
9	Affinity Sutton, FutureFit	FutureFit is an integrated model of retrofit delivery for 102 properties, ranging from the definition of retrofit packages with various cost brackets, resident engagement and performance monitoring.
10	City South Manchester, Hulme Tower Blocks	Hulme Tower Blocks were externally clad, with innovations in the development of the supply chain and engagement of residents.
11	Southern Housing Group, Green Doctor	The Green Doctor Initiative was concerned with training residents to act as community advisors to support individuals in their energy use, providing a mixture of advice and basic retrofit measures.
12	Octavia Housing, Passiv Haus	Early example of the application of PassivHaus approach as applied to retrofit.
13	EnerPHit	EnerPHit is an emerging retrofit standard that connects with PassivHaus principles. This is an early example of the pilot project delivered through the TSB Retrofit for the Future Programme.
14	Fusion21, Retrofit Frameworks	Fusion21 is a social enterprise that is developing a holistic delivery model addressing technical, commercial and social aspects of the retrofit delivery process. It uses the procurement framework as a vehicle to deliver jobs and skills to local residents.
15	Urbed, Rotherham Retrofit	This multi-house retrofit project was delivered as part of the TSB Retrofit for the Future programme to demonstrate large carbon savings for a lower cost, driven by a fabric first approach.
16	Salix Homes, Islington Art Engagement	A series of arts projects used to promote and engage residents with retrofit concept and

		process.
17	Urbed, Carbon Co-operative	Based on the Community Green Deal Report, this model is designed to create a social enterprise that will be able to channel funds, such as the Feed in Tariff and Renewable Heat Incentive, to support neighbourhood retrofit driven by local residents.
18	Salix, Regents Park Estate	This project looked at innovative ways of trying to engage mixed tenure in neighbourhood level retrofit to drive economies of scale and avoid the issue of "pepper-potting" of properties, which can reduce both efficiency and effectiveness of retrofit.

4.2 Type of Innovation – Product, Process, Position, Paradigm

Table 3 shows the distribution of the types of innovation across the 40 identified innovations within the 18 case studies. This distribution should be taken with some caution as the focus of the study was generally biased away from projects with a purely technical solution. This does mean that there is a natural skew towards process innovations. Positioning innovations are generally concerned with branding, where traditional approaches are often being rebranded for new sectors. This is generally seen where social housing providers are looking to engage outside their traditional resident markets and extending into owner-occupier or private rented sectors. The paradigm innovations are concerned with new models for doing business within the retrofit market. The two examples, Pay as You Save and Community Green Deal, look to deliver retrofit in a way not yet fully seen in the market. However, these models represent precursors to the forthcoming Green Deal, which will be come into force in 2012 as part of the new Energy Act. This shows how paradigm innovations of only a short time ago, 2010, can become mainstream, indicating how quickly new ideas are being adopted within the retrofit field.

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Table 3 – Innovations Distributed by Francis and Bessant Typology

Innovation Type	Number
Process	25
Product	11
Position	3
Paradigm	2

4.3 Type of Innovation – Incremental, Architectural, Modular, Radical

Table 4 shows the distribution of innovations according to the Henderson Clark Model (1990). What can clearly be seen is that the innovations themselves are often adaptation of existing approaches applied in a new context. Many of the innovations could be described as a reconceptualising of old ideas, such as supply chain management or resident engagement, or a recombination of existing ideas into new forms in terms of architectural innovation. This potentially identifies retrofit as nothing new in terms of its elemental parts, but provides a context for the reshaping and recombination of many of these ideas.

Table 4 – Innovations Distributed by Henderson Clarke Model

Innovation Type	Number
Incremental	35
Modular	0
Architectural	5
Radical	0

4.4 Key Findings

The high-level issues are those that have been identified across the cases and have implications for the consideration of innovation in sustainable retrofit.

The sustainable retrofit of domestic properties is being viewed in a systemic way by early adopters. Projects such as EcoPod, Community Green Deal and Fusion21, underline the application of systemic thinking to ensure the delivery of a built environment with improved energy efficiency. This means that technological choices have to be considered in the wider context. Success was often driven by the innovation being supported by a range of other innovative activities that were linked. Innovations concerned with the physical process of retrofit were very rarely seen in isolation. This could be because the teams were innovative and saw multiple opportunities to innovate, but also it could be considered that the new nature of the problem required additional innovations to make the proposed innovation work in an effective way. The socio-technical approaches highlighted by Geels (2005) are useful in identifying the inter-connectedness of rules, artefacts and actors, which can be seen as playing out in many of the cases. The planned multi-faceted responses undertaken in many of the cases shows that industry also recognises this issue.

Virtually all of the innovations were undertaken in projects that were in some way supported or subsidised. Some of these were funded research projects, such as the Technology Strategy Board’s Retrofit for the Future Programme; others were funded through subsidies that were delivered through the energy companies’ obligations such as the Carbon Emissions Reduction Tariff (CERT) and CESP. This raises the question as to whether, at this stage, the energy savings generated through sustainable retrofit can be seen to have a well-defined business case. Consequently, the innovations that occur are pushed by policy/regulation rather than pulled by the market. Additionally, as many of the cases were demonstration projects, there was a project team commitment to innovate around the retrofit issue.

The sustainable retrofit of the built environment, particularly at scale is a new area and there has yet to be an established dominant paradigm, i.e. there is no fixed approach to address sustainable retrofit from either a technical or process perspective. The industry is very much in a learning stage, with activity often running ahead of the evidence. An example of this can be seen in the adoption of urban micro-wind turbines in many developments, an approach that was generally discredited in the Warwick Study (Encraft 2009).

4.4.1 Process Innovations

Process innovations covered much of the delivery process, ranging from procurement approaches to asset management as a driver for retrofit. Effective procurement has an important role to play. The Decent Homes Programme in the UK was delivered using innovative procurement frameworks, which created opportunities for groups of clients to amalgamate demand creating benefits in terms of costs for clients, as well as reducing bidding costs and smoothing workflow for construction companies. Fusion21 has applied this model to the retrofit market. A number of the cases (EcoPod, Whiscers) have identified Off-Site Manufacture (OSM) as an important process opportunity. OSM helped address two key issues identified as problematic within sustainable retrofit. Firstly, the level of disruption, identified as one of the main barriers to sustainable retrofit adoption, was greatly reduced through the application of OSM. Secondly, the levels of accuracy, particularly around internal and external wall insulation have been greatly improved. The role of the supply chain has been identified as an essential component of any large-scale sustainable retrofit at a national level. Fusion21 and Community Green Deal identify the development of the supply chain as core to their ideas of effective and lower cost delivery.

A number of the cases are looking to the collection of data and first run studies (Salam et al 2006), a lean construction principle, to try and establish an evidence base. Affinity Sutton are developing a number of base cases for the retrofit of property, which could potentially be viewed as first run studies. These are sustainable retrofit approaches that will be feasible at scale, looking at a demonstrator with an effective underlying business case, rather than solely a demonstration of technological innovation.

Despite the lack of established rules for undertaking sustainable retrofit, there were some emergent rules that were identified in the case studies. Trigger events were identified as points in normal maintenance that could be used as an opportunity to implement a sustainable retrofit approach, as seen in City South. The other approach identified was "fabric first" i.e. the fabric should be addressed prior to any systems upgrades. Although, from an engineering perspective this appeared to be taken as read, there were still examples, outside of the cases where this approach was not considered.

4.2.2 Residents and Communities

The evidence from the cases suggests that residents were seen as central to the retrofit process. Residents must be convinced to adopt sustainable retrofit, especially when they are making the investment decision. Interviewees identified that provided solutions must perform as intended without impacting the residents comfort or lifestyle, otherwise behaviours will be created that render any improvements ineffective. Approaches, such as OSM identified above, recognise disruption as a significant barrier. Products and processes were considered and issues of disruption engineered out where possible.
Case study participants stated that sustainable retrofit and the issues that surround it are complex and may be difficult for people to engage with. Engagement approaches varied in the cases in terms of extent, but at the very least a basic level of engagement was seen as essential if the project was to be successful. Engagement at an individual level is

important, however, some of the cases identified how the power of community relations could be harnessed to drive higher levels of engagement. The involvement of local people in delivering retrofit or providing advice created levels of trust and information sharing that were generally considered more effective than more traditional business to customer, marketing-based approaches.

New technologies can meet resistance. It is important to recognise that people's systems in their homes are "culturally embedded" in their day-to-day life and changes to this can be difficult for people. Approaches can be adopted to address this and reduce the level of resistance, either through support or training or effective product design. This can be clearly seen in the EcoPod model where fake fires where installed, as the previously installed gas fire were seen as a design focal point for many of the residents. It can be difficult for individuals to understand the proposed changes to their homes without physically seeing what they might be. The cases used demonstrations of products and show homes to overcome this barrier.

4.2.3 Monitoring and In Use

Some of the cases show how the teams recognised a need for better information to evaluate retrofit performance, above and beyond the traditional models of the Energy performance Certificate, based on reduced data SAP (rdSAP). The EcoPod had a building management system that identified energy used by residents. This identified "deviant" energy behaviours and focused actions around the small percentage of energy users who were responsible for the most energy use. This also identified that the range of energy use between residents in similar units could be as much as four times the average. Affinity Sutton have developed an experimental monitoring approach to try to effectively identify the factors the driver energy use, including demographics and behaviour.

A sustainable retrofit solution should not be viewed as a "one-off". Even for individuals who own their own homes, an understanding needs to be gained around the operation, maintenance and whole life cost issues of any approach. The solution from the EcoPod case not only reduced energy use, but also greatly reduced the requirement for operation and maintenance, as well as increasing resident safety. There was also an identified need to understand issues of in-use maintenance and advice supply chains. This may range from the ability of a resident to find a company to repair or maintain a specific intervention, which may be difficult for new products, to wider advice with regards to operating new equipment. Community advisors and trained social housing representatives were seen as addressing this need.

4.2.4 Finance Pricing Models

The UK is currently experiencing a major overhaul of policy, which will create a very different financial context for decisions made around sustainable retrofit. Some of the cases show the experimental phases for some of these policy initiatives, as well as different models of supplier-consumer relationship. Understanding how different financial mechanisms is an important part of retrofit. Models such as Pay as You Save, soon to be developed into the Green Deal, Feed in Tariffs and other forms of incentives can change to patterns of adoption, by changing the financial landscape.

Pricing of energy is important – the generation of cheaper energy, or the changing of pricing patterns can create unexpected consumption patterns. Examples within the cases showed that project teams recognised, or very quickly learned that changes to energy use will not necessarily create rational or linear changes in consumption. This is particularly important when considering a possible business cases based on projected energy savings.

4.2.5 Economic Development

Economic development has been viewed as an explicit part of both national policy and some of the cases in this study. Fusion 21 and Community Green Deal looked specifically at the opportunities that can arise from significant spend within the construction industry. At the most basic level, a large-scale sustainable retrofit programme can create a large number of jobs, ranging from support and advice to installation and manufacturing. Using a purely economic model to establish a business case for sustainable retrofit does not appear to be entirely applicable. Social Return of Investment models have been applied. These models may include factors such as carbon emissions, health, jobs and other external factors, highlighting the wider benefits of sustainable retrofit.

4.2.6 Brands and Standards

The developmental nature of the sustainable retrofit domain has been highlighted. This means that standards are emerging, with government attempting to balance protection for the consumer while driving innovation. Many products and related processes are still in the developmental stage. Different approaches may have been applied in limited numbers of demonstration projects, so standards have yet to emerge. Brands and the related trust may be viewed just as importantly as standards. The UK has many owner-occupiers who will not have requisite knowledge, so a trusted brand, such as that being developed by Relish, can have a positive role in promoting the take up of sustainable retrofit among individuals who are making investment decisions based on less knowledge.

5 Conclusion and Further Research

The cases reinforce the view that the challenge of addressing the energy efficiency of the UK housing stock is not merely a technical one. Effective linkages between policy, process, finance, and people issues are required to ensure that the technical solutions that are being developed can be effectively adopted, implemented and used in the long-term. The issues raised by the case studies provide a compelling argument for the problem to be framed within the context of socio-technical systems models. Understanding the inter-linkages is important to help us understand what is feasible is a real world context. Innovation for sustainable retrofit needs to be understood in a way that extends beyond the development of products. Communities of practice need to extend to include a wider number of actors to appreciate how far reaching the inter-linkages are. Changes in policy in the area of sustainable retrofit are moving quickly; by 2012 we shall have the implementation of the Green Deal. On the surface this seems a simple of model of repaying finance through energy savings, but the cases here reveal the links between policy makers and regulators, end users, finance companies, construction companies and their supply chains, education and skills organisations and product suppliers all need to be considered if the integrated approach is to be successful when sustainable retrofit progresses from demonstrator to large-scale delivery.

The range of the innovations within the case studies shows the breadth of issues that both the research and practice communities have to address. Oreszczyn and Lowe (2010) identify the necessity to link the disciplines if we are to address the problem, but they also identify a need to better link the research base with the practice base. This is not a call for simply better dissemination, but the need to engage in co-productive action research based models. It is clear that the case here show that social housing providers and their supply chains have an appetite and willingness to engage in research type activities and could benefit from the tools and perspectives brought by the research community when working in partnership.

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