Article:

Owen, A, Mitchell, G and Gouldson, A (2014) Unseen influence-The role of low carbon retrofit advisers and installers in the adoption and use of domestic energy technology. Energy Policy, 73. 169 - 179. ISSN 0301-4215

https://doi.org/10.1016/j.enpol.2014.06.013

Title: **Unseen influence – the role of low carbon retrofit advisers and installers in the adoption and use of domestic energy technology**

Authors: Owen, A, Mitchell, G and Gouldson, A

Corresponding author:

Dr Alice Owen a.m.owen@leeds.ac.uk Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK tel: 0113 343 6411

Co-authors

Dr Gordon Mitchell g.mitchell@leeds.ac.uk School of Geography, University of Leeds, LS2 9JT, UK

Professor Andrew Gouldson a.gouldson@leeds.ac.uk Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK

Unseen influence – the role of low carbon retrofit advisers and installers in the adoption and use of domestic energy technology

Abstract: Reducing climate changing emissions associated with residential property continues to be a significant challenge. Five case studies of different domestic energy technology schemes in England highlight the influence of advisers and installers in householders' decisions to adopt low carbon technologies. Many of these advisers and installers are micro-enterprises working in connected groups in particular geographic areas. Such micro-enterprises form a large part of the construction sector, but despite the number of enterprises and the potential impact of changes in the behaviour of the sole traders and small firms, there appears to be little policy that specifically targets this group. Data from these case studies is presented and organised into a typological framework, in order to illustrate the range of ways in which the impact of advisers and installers can be modified. Two of the six factors in the typological framework relate to the motivation of installers themselves and how their work is perceived by their clients. By examining these factors in particular, this paper makes a novel contribution to understanding the factors that influence the take up and use of domestic energy technologies, leading to the possibility of new policy options or interventions.

[193 words]

Keywords: technology diffusion; intermediaries; retrofit

Highlights

- Five UK schemes to promote domestic energy technology are examined
- Advisers and installers influence the impact of energy technology
- Micro-enterprises dominate low carbon retrofit
- Low carbon retrofit installers are beyond the reach of current policy
- A framework for investigating installer competence is proposed

1.0 Introduction

In the ongoing challenge to mitigate climate change, tackling carbon emissions associated with buildings remains important. While new buildings can be designed and constructed to ensure lower levels of energy demand and associated emissions, existing buildings must undergo technological retrofit. The ideal opportunity for retrofit is at a point where there is a change in the building's function, a change of occupant or a change of lifestyle or routine (Schäfer et al., 2012). In developed countries, where rates of new build are low compared to the stock of existing buildings, retrofitting buildings is a major element of achieving carbon reduction targets. In the UK, it is estimated that approximately 75-80% of the UK's 2050 building stock already exists (SDC, 2006). Within the total building stock, domestic (homes) and non-domestic properties demand different interventions. UK homes accounted for 25% of UK emissions and 40% of energy use in 2009 (DECC, 2011), so focussing on residential property alone could still offer a significant contribution to meeting carbon reduction targets.

This paper arises from research focussing on how technology can reduce domestic emissions when part of a retrofit project. There are three ways in which domestic technology might make a contribution: curtailing energy use, improving energy efficiency (Gardner and Stern, 2002) or increasing microgeneration. Energy efficiency can be improved by deploying technologies, such as insulation, which reduce energy losses, or by improving energy use efficiency directly, for example through the adoption of energy efficient lighting and appliances. On the domestic scale, renewable microgeneration technologies that might make a contribution (if correctly installed) include solar thermal systems, heat pumps or biomass boilers for heat, and solar photovoltaic (PV) cells, wind turbines and micro-hydro turbines for electricity (Bergman and Jardine, 2009). There may be additional indirect carbon reductions from technology installation; it has been suggested that households that have microgeneration technologies installed also make behavioural changes to reduce demand (Dobbyn and Thomas, 2005).

Modelling suggests that up to 40 $MtCO_2e$ could be removed from UK residential emissions by 2020 if energy efficiency measures and lifestyle changes were implemented, with a further 60 MtCO2e reduction possible via domestic renewable microgeneration, although this is more expensive (CCC, 2008). The CCC's realistic forecasts of what could be achieved by 2020 are 9-18 MtCO2e from energy efficiency and 10 MtCO2e from microgeneration. In the UK, policy packages such as the Green Deal and the Energy Companies Obligation are fundamental to achieving low carbon retrofit. Green Deal is a scheme which allows private householders to repay the costs of energy efficiency improvements through their energy bills rather than needing up front capital payments. The Energy

Companies Obligation complements the Green Deal by placing a legal requirement on energy suppliers to implement energy efficiency measures, particularly for more vulnerable groups of energy users.

Energy technology retrofit clearly has potential to deliver significant emission reductions, but in practice, the success of retrofitting existing building stock to low carbon standards is dependent on social, cultural and economic change as much as technical innovation (Ravetz, 2008). Here, we investigate the role of a largely overlooked change agent in this broadly conceived retrofit process, the energy technology installers and advisers. We explore the interaction of these agents with householders in an effort to better understand their role and influence in the domestic energy retrofit process. We begin by briefly reviewing the factors that affect uptake and use of domestic energy technologies, before moving to the main focus of this paper, the influence of installers and advisers. We explore the role and impact of the adviser and installer through analysis of primary data from five English case studies. We conclude that their role is significant but that some of the characteristics of a large proportion of the advisers and installers mean that they are beyond the reach of current policy interventions. A framework for understanding individual adviser/installer attributes and competencies is developed, which we suggest can help to identify how policy and practice might reach these key individuals and unlock their potential to contribute to, and accelerate, the essential low carbon retrofit of the domestic sector.

2.0 Literature Review

Before the explicit consideration of the role of advisers and installers in energy technology adoption, it is useful to review, briefly, the factors that affect adoption and use of energy technologies in the home as this helps to understand the context in which these key intermediaries operate. The key factors important in energy technology adoption include the technology, its users (in our case, householders), and characteristics of the place where the home is located.

A first set of issues relates to the characteristics of the technology itself. Rogers (2003) suggests that around half of the variation in the rate of adoption of a new innovation can be ascribed to five characteristics of the innovation itself: the relative advantage it provides to the user, its compatibility with existing systems, its observability, trialability and perceived complexity. In the UK, the diffusion and impact of energy technologies (including cavity wall insulation, solar water heating, photovoltaic (PV), compact fluorescent light bulbs, central heating controls and condensing boilers) has been researched in depth, with a view to informing energy technology design and closing an observed gap between intended and actual impact (Caird et al., 2008; Roy et al., 2007). The research examined the motivations of, and feedback from, non-adopters (who have not considered adopting low carbon technologies), rejecters (who have considered adopting but decided against it), as well as actual adopters. This framework adapted the five technology attributes central to innovation diffusion as suggested by Rogers (2003), and proposed four related innovation attributes: price, usefulness, interconnectedness (the degree to which a technology is dependent upon, or closely linked to, a range of other technologies or services), and symbolism (the meaning the technology has for the user beyond its design function). The importance of these factors varied between technologies. Examining the diffusion of these energy efficiency investments amongst UK households, the desire to save energy, save money and have a warmer home were the three main motivations for adoption of loft insulation, heating system controllers, condensing boilers and energy efficient lighting. Expense, and the (perceived) difficulty of installation (of the whole process e.g. clearing the loft as well as laying down insulation) were significant barriers to adoption and a range of product design improvements were suggested that would help to overcome such barriers (Caird and Roy, 2007; Caird and Roy, 2008). Other analysis has shown that energy costs and technology prices matter in the decision to adopt a technology, but finance alone is not enough to achieve change without the influence of other factors (Jaffe and Stavins, 1994). Price is also not an absolute barrier but a relative one, working in combination with household income.

A second set of issues relates to the characteristics of the users of the technology. While the adoption of a domestic energy technology is a necessary stage in achieving reductions in resource use, it is the use of that technology that leads to its impact. This leads to recognition that, in addition to the characteristics of the technology itself, the user's attributes will also affect technology adoption and how it is used. Such attributes include the household's attitudes towards the environment (e.g. Fishbein and Ajzen, 1975; Mirosa et al., 2013), their values (Stern, 2000), perceived behavioural control (Ajzen, 1991) and habits (Marechal, 2010; Shove, 2009). These individual factors interact with the household's socio-economic conditions. For example, early adopters of microgeneration in the UK were found to be older householders (with more available capital) in larger, detached, rural locations (Roy et al., 2008).

The third set of characteristics that have been found to influence technology adoption and use relates to the place where the technology is installed, with the location of a property affecting the feasibility of a specific technology. For example, lower latitudes have more incident solar radiation, enhancing the performance of PV cells, although studies of the adoption of PV in the USA found that incident radiation was not the only important factor, with state incentives to support technology also being important (Kwan, 2012). A south-facing roof with a particular pitch is optimum for PV; a sheltered external area assists a heat pump fan; storage is essential for biomass boilers, and so on (Pester and Thorne, 2011; Thorne, 2011a, b). However, the more subjective characteristics of place (Tuan, 1990) rather than location also have an influence. The case studies presented below found that 'acquired attributes of place' (Lupton and Power, 2002) are particularly important in creating the context for accelerating technology adoption (Owen, 2013). The availability, strength and effectiveness of location-specific social and learning networks have also been found to have an impact on the diffusion of energy efficiency innovations (McMichael and Shipworth, 2013). The effects of social networks on the adoption of energy efficiency measures has been modelled in a city-specific context, which found the level of activity that a household had in social networks to be potentially an important variable in that household's behaviour (McCullen et al., 2013).

There are several non-technical barriers to achieving technologies' potential for reducing domestic emissions. These include the rebound effect, the "energy gap" and the "value action gap". Rebound effects are calculated as the percentage of expected benefit that is lost in implementation. For example, energy efficiency technologies, such as insulation, may make energy services such as heat or light more affordable, so that the homeowner uses more energy while maintaining or even reducing energy bills (Sorrell, 2007). A UK review of energy efficiency studies found direct rebound effects were typically 10-30% (Greening et al., 2000). A more recent US assessment has suggested that the lower end of this range is most likely (Nadel, 2012). The "energy gap" (Jaffe and Stavins, 1994) highlights that energy conservation technologies are not adopted in ways that align with rational economic models. As with energy efficiency measures, microgeneration in the UK lags behind levels that appear economically rational (Bergman and Eyre, 2011). Another gap, the "value action gap" describes how individuals' pro-environmental attitudes and values do not translate into pro-environmental actions (Blake, 1999).

These observations remind us that technology alone cannot achieve the desired reductions in resource use, and that the human dimension must be addressed and understood in order to promote the carbon reduction benefits of domestic energy technologies. To date, the focus of analysing this human dimension has been on the householder, and determinants of their behaviour. However, a further group, technology advisers and installers are potentially significant players in low carbon retrofit, and have to date been largely overlooked in this research area. Below, we focus on these intermediaries and, through analysis of case studies in five English regions, seek to gain insight into the role they play in the promotion, installation and use of low carbon domestic energy technology.

The main focus of our analysis is on those who have been termed ‘change agents’ (Rogers, 2003) –in this case, the advisers who liaise directly with householders to identify and recommend retrofit technologies, and the installers who put those technologies in place. In many cases these two roles merge, with installers advising on appropriate technologies and then specifying, costing and implementing those solutions. Reflecting this, we use the term adviser/installer where roles are combined.

Those involved in specifying solutions ostensibly offer advice on technology selection but, by implication, their advice also impacts on behaviours relating to energy consumption. The installers/advisers role becomes clearer when a socio-technical systems perspective is applied, highlighting how many actors and technologies across the whole supply chain and use system work together in an interconnected way (Clegg, 2000) to shape a particular household behaviour (like technology use). Banks (2001) study of high efficiency boilers, before the technology was effectively made standard by regulation, identified the critical role and influence of the intermediary (in this case the heating engineer) in shaping the decision to adopt. This analysis found that the factors that shaped an installer’s advice to a household included cost, preference for a given manufacturer and the fit between their technical understanding of the technology and what they believed their customers valued, and would therefore pay for. A more recent socio-technical exploration of the capacity and willingness of construction businesses to integrate low carbon technologies identified a range of factors including how the SME links to other trades and professionals in a project, the inevitable unpredictability of retrofit projects and how previous experience and product design shape attitudes to risk and innovation (Killip, 2013). The role of “craftsmen” in influencing the impact of renovation measures on energy efficiency has been identified in a recent Norwegian study (Risholt and Berker, 2013) and the call has also been made for more consideration of adviser/installer skills issues in policies for low carbon transition (Jagger et al., 2012).

There is also a potential role for advisers or installers in tackling the problem of getting people engaged with energy efficiency or carbon reduction initiatives and becoming “energy citizens” (Devine-Wright, 2007). While the rationale for reducing or changing energy consumption patterns seems compelling to many scheme designers, the public are not convinced enough to take action. For example, one of the case study schemes in our research, Kirklees WarmZone (see Table 1) failed to contact approximately 16% of households in the council area over the three years of the scheme, despite at least three attempts to contact each householder by letter and in person at different times of day on different days of the week. The WarmZone scheme offered free insulation as part of a package of advice that could cut fuel bills and increase the comfort and safety of homes (Kirklees

Council Environment Unit, 2011) but these benefits were insufficient to engage all possible households.

Advice for households on the selection of pro-environmental technologies, and on behaviour change to reduce energy bills, comes from myriad sources. We focus on those who might offer advice to individual households as part of a retrofit project. A retrofit or refurbishment project does not have to be primarily identified as “low carbon” in order to offer low carbon opportunities; indeed, a general renovation project may easily be “stretched” to encompass low carbon outcomes, but only if the adviser or tradesmen involved are motivated to suggest such changes to the original specification (such advisers might be from NGOs, local authorities or their agencies, or from the commercial sector. An EU review identified multiple roles for these energy advisers including the provision of support in the process of taking action, as well as assessing possible routes of action (Maby et al., 2007), but it has been suggested that it might be more helpful to create a typology of advice, rather than advisers, with potentially six advice levels ranging from generalised support, to in-home bespoke design and support in implementing changes in lifestyle (Maby, 2009). Research into water conservation behaviours has found that different levels of advice have different impacts, although all impacts eventually disappear after advice ceases to be provided (Fielding et al., 2013). It is therefore important to consider what advice is offered to the householder in terms of maintaining their modified property, or in getting optimum benefits from their retrofit activity. Motivation, incentives and the level of advice offered varies between these different types of advisers depending on their personal values and their organisational context. Motivations, which are not mutually exclusive, might be to reduce resource use, to tackle fuel poverty, to improve the quality of the housing stock or to reduce energy bills. Income from advice activities might be tied to time, expertise, households advised or installations achieved, but carbon or resource use reduction is rarely translated into an income stream.

A survey of US home energy auditors found that nearly half of auditors were energy efficiency or building consultants, with just over one third of the other half of auditors in construction and utility companies, and a small number from non-profit or training organisations (Palmer et al., 2013). This survey revealed that only a minority provide home energy audits to those who voluntarily seek them, with most audits being carried out as part of a scheme where the audit is a requirement or an incentive (Palmer et al., 2013). These niches of activity may be spatial if created by local policy, or technology-based if created by national policy. The technology-based niches lead to a cohort of installers who tend not to be tied to particular locations, allowing them to undertake work wherever a technology is supported (Jagger et al., 2012). However, many of the smaller, ‘mainstream’ installers are rooted in one geographic area making them less amenable to implementing new technologies where there are no local drivers complementing the national policy.

There is some evidence that installers' enthusiasm for public policy and associated schemes is linked to what those installers believe their customers want. Some installers may be sceptical about whether customers would want energy efficient technologies if there was no grant support available, and they may therefore be wary of making their businesses dependent on such technology, given that public policy is likely to change (Gillich, 2013). Specification of suitable technologies may be a formal part of the job for architects or for heating engineers, or it may be less formally done as a job progresses in a more iterative design process. In the latter case, the builder, the heating engineer or plumber and the electrician working on a property will often collaborate, sometimes with the client householder, to identify solutions and specify work.

There appears to be a spatial aspect to how installers and advisers work, although this needs further investigation. Not only do they tend to work in a concentrated way in particular areas, led either by funding or by their existing client base and social networks, but individual firms often collaborate in networked groups building up shared expertise. Overlapping groups of small firm collaborators will often use similar merchants to source their materials. Builders' or plumbers' merchants may be where individuals have the opportunity to acquire and share knowledge in a non-competitive way. Other researchers have observed that networks of micro-enterprises may collaborate in order to challenge current practice and create a "pathway" to a different practice in the retrofit of heating systems (Heiskanen et al., 2011). Contrasting the influence and networks of installers operating in the niches of microgeneration with the more mainstream building trades could provide valuable insights into how policy and skills support might be spatially targeted. The adviser/installers' networks of knowledge, value and motivation are important for the micro-enterprises, but their spatial extent, links to other social networks, and stability over time appear not to have been little investigated. This is particularly evident in the context of a low carbon transition, and despite their potential influence in accelerating low carbon retrofit, installers and advisers appear to be outside the influence of policy interventions such as financial rewards for economic growth or environmental performance, or environmental accreditation schemes.

Employment data helps illustrate the number of advisers/installers in the UK, and hence acts as an indication of the potential significance of these intermediaries in the low carbon transition. Figure 1 shows how three quarters of all firms who work on residential property employ three people or less (Office for National Statistics, 2012) while the proportion of such small firms is slightly higher for the allied trades of electricians, plumbers and heating engineers. For these three groups alone, a conservative estimate, allowing for one person per firm only, is that there are 95,000 individuals in these types of firms whose work could influence and accelerate domestic property retrofit in the UK. In March 2013, 269 000 individuals were registered as self-employed across the whole construction of buildings sector in the UK, about 0.9% of the UK workforce (Office for National Statistics, 2013).

FIGURE 1 about here

The work carried out by these smaller enterprises is an area of significant economic activity. The potential market spend on 'repair-maintenance and improvement' (RMI) of private homes low carbon retrofit on a room by room basis, was estimated at £12.5 billion per annum in 2009 (45% of the RMI spend that year), compared to a spend on energy efficiency by the larger energy companies through the CERT scheme of £800 million in the same year (Killip, 2012). If, however, the installation of domestic energy technology through retrofit is considered a mainstream construction issue, then the potential economic impact rises to aligning the whole £22.3 billion spend on main trades for RMI of private housing in 2011 (Office for National Statistics, 2012) with low carbon goals. This would be consistent with the householders' interests and motivations in many cases. The quest for energy efficiency alone is unlikely to be the driving force behind the decision to undertake renovations, which are more often motivated by the desire for different living space (Maller et al., 2012; Risholt and Berker, 2013). However, a renovation or RMI programme provides the opportunity for energy efficiency improvements and makes it more likely that energy efficiency improvements can be achieved.

Having described the advisers/installers and their potential role in accelerating low carbon retrofit, we now turn to examining the data from five English case studies to generate an empirical typological framework for the adviser/installer competencies.

3.0 Material and methods

Research was conducted to explore the role and importance of advisers/installers in practice, based on qualitative case study research that examined householder, installer and project manager/promoter perspectives in five area-based schemes that promoted different forms of domestic energy technology. After a short description of the case studies, results that illustrate the differing roles and perspectives of installers and advisers are presented. This empirical work leads to a proposed framework for examining the capability (competence) for adviser/installer impact, defined in terms of effecting a household transition to lower carbon living. The focus throughout remains on the adviser/installer as an individual, rather than the wider system in which they operate, although clearly this wider system needs to be taken into account. Table 1 provides a summary of the five case study schemes.

Table 1 about here

The five case studies were designed as part of a wider study intended to identify the factors that affected the adoption and use of domestic energy technology in the context of area-based schemes. Data was gathered from households that had adopted technology under the schemes in question (adopters), householders who had considered adopting but had not proceeded (non-adopters), the scheme managers, and the installers and advisers who specified the technology interventions and interfaced directly with the households. In addition to the data gathered from the case study schemes, a small number (3) of serial adopters of energy technology were interviewed so that the extreme position on the adoption curve, the innovator, could be included in the analysis and compared with more mainstream projects. A total of 54 semi-structured interviews (summarised in Table 2), fully transcribed, and participant observation, resulted in 62 texts for thematic analysis. The illustrative results offered here complement a wider set of results addressing other factors, such as role of place, discussed elsewhere (Owen, 2013).

Table 2 about here

A pilot investigation found that in addition to the three sets of factors predicted from theory (technology, users and place – see above), advisers/ installers also influenced the adoption process. This was consistent with the assertion from some practitioner literature that without expert advice, suboptimal decisions will be made by householders (Platt et al., 2011). While pilot investigation finding was influenced by one of the pilot sample being an adviser and installer (for loft and cavity wall insulation) it led to the impact of installers and advisers being included in the full thematic analysis.

Once the full data set was assembled, the data was analysed using a template of themes derived from the literature supporting the wider study, which had earlier developed a conceptual model to facilitate examination of the factors that affect the adoption of domestic energy technology (Owen, 2013). Template analysis allowed the data to be analysed through the lens of that proposed model, looking for evidence that fitted with a priori codes (King, 2004; Waring and Wainwright, 2008). Codes reflecting the conceptual model were established in the computer aided qualitative data analysis software.

4.0 Results

The first theme to emerge centres on the technical capacity of the adviser/installer and their ability to tailor solutions to a specific household and context. In the REcharge case study, one individual had been responsible for advising over 300 households on feasible microgeneration technologies. While using technical knowledge to identify feasible technologies was essential as a starting point, this adviser and qualified installer filtered what was technically feasible to suggest only technologies which would meet the householder's needs and potentially reduce energy costs. This is typified by the decision on whether to advise on solar thermal or PV installation. If the household did not have children at home and appliances were modern (cold feed dishwashers and washing machines) then the financial benefits of PV from the Feed in Tariff (FiT) were considered more advantageous than the energy bill reductions from solar thermal. Referring to solar thermal systems, this adviser noted:

> *"And quite often I'd have to say 'I'm terribly sorry but it isn't worth your while. I know they're going to give you ten grand to do it, but you'd never use it.... 'Really, it's not a go-er for you'. Three kids kicking around, yes, you're going to use all the hot water it can generate every day ... so that's fine. But for some people it's just not worthwhile." [Adviser / Installer, RECharge]*

Advisers/installers were observed in RE:NEW gathering information on the household before any interactions with the householder. The RECharge and ERYC ASHP advisers reported similar data collection as part of their work processes. This might be done through assessing a property's attributes in terms of its location and other known installations in close proximity, or it might be done on the way to the front door where the adviser/installer is looking for signs of life-stage (children's toys in the front garden, etc.), assessing the state of repair of the property, whether it appears to be well insulated and so on.

Advisers/installers demonstrated a sophisticated understanding of the technology attributes beyond technical performance. They noted the appeal of visibility and the "gadget factor" in the wireless energy monitors, also recognising that this appeal was demographically dependent and less important for the elderly. Advisers/installers stated that the visual appeal and compatibility of the technology with the homeowner's existing systems and aesthetic was a critical factor in adoption:

> *[Referring to the low flow showerhead] "This comes back to the shiny thing. I don't know whether you've seen one of them but they're very nice, faux chrome things, they look nice and they look good. And in fact the bottom line of where stuff gets in or not is whether or not somebody feels it's in keeping with their house." [Adviser/Installer, RE:NEW]*

In Totnes, the intention to adopt was formed by the peer learning process and the adviser/installer's role was simply to assess the suitability of the roof for PV. However, in the RECharge process, without the neighbour connection provided by the Transition Streets approach and where many more technologies were available, the role of the adviser/installer was critical, remarked upon by adopters and non-adopters as well as by the scheme facilitator. Installer experience was one of the criteria used in tender evaluation when selecting a managing agent for the scheme. One of the heating engineers who specified the air source heat pump (ASHP) systems in the East Riding emphasised that every home was different. Even if the layout and orientation had originally been identical, in his view it took less than two years for householders to impose their unique modifications and usage patterns, requiring a bespoke retrofit.

Effective advisers/installers understood the role of the household or individual users in the impact of any technology. In the RE:NEW scheme, advisers/installers placed more focus on user characteristics influencing use than facilitators did, and also brought technology attributes to the fore in considering the use of the technology. It is worth noting that advisers/installers understood the risk of discontinuance:

> *"With the thermostat it's impossible you might say, "Well, you might just want to nudge it down and shall I just do that?" Obviously somebody could whack it up a bit later on." [Adviser/Installer, RE:NEW]*

The second theme to emerge from the data moved away from technical competence and into the area of an adviser/installer's personal impact as the worked with, and in, a household. In the RE:NEW London scheme, advisers/installers recognised that the way they approached the householder and tried to understand what drove their behaviour would help their advice take hold and ensure the energy conservation measures were accepted. Advisers/installers also understood the need to demonstrate the relative advantage of a technology in a way that really struck home with the potential adopter. In one visit, while using the wireless energy monitor to demonstrate the running cost of different appliances, the householder screamed her surprise when the electric shower was turned on. The installer later remarked:

> *"The shriek at the energy monitor is the result I'm gunning for!" [Adviser/Installer, RE:NEW]*

The challenges that arise from dependence on advice from individuals were also recorded. In RECharge, a small number of adopters and non-adopters also felt that they could not get the level or certainty of information that they wanted, particularly when their best solution may not be straightforward. Advisers recognised that lack of confidence in the advice offered could lead to non-adoption.

In Kirklees WarmZone, the positive reputation of the adviser/installer firm in the area and the firm's high level of visibility (developed because of the nature of the scheme), were mentioned as important in ensuring households moved from intention to adoption. Advisers/installers themselves often realised the complexity of their tasks and how they might influence a householder in making their decision to adopt. Advisers/installers and facilitators in WarmZone, and RE:NEW made direct connections between how the adviser/installer presented themselves, and whether the householder would be persuaded to adopt the technology.

As well as these interpersonal skills, the personal motivation for advisers and installers influenced the advice they offered and its impacts. This was particularly noticeable in the NGO-led Transition Streets Totnes scheme where the adviser/installer was aware of the potential for PV installation to bring wider benefits in reducing resource consumption and considered it part of his role to highlight these benefits:

> *"That's my personal crusade here, is the energy awareness." [Adviser/Installer, Totnes]*

Aspects of personal motivation were believed to be a potentially limiting factor on the positive impact of the adviser/installer's work. Adviser/installers commented that where an adviser/installer is very passionate about environmental outcomes, they may take an evangelical approach to the advice they give. Advocating a reduction in energy consumption on moral grounds was not considered to be helpful by other adviser/installers who observed this approach used by colleagues. Even though in RE:NEW, RECharge and in Totnes the adviser/installers owned strong personal commitments to reducing resource consumption and waste, they were careful not to impose this commitment on their clients in an emotive way.

The adviser/installer in Totnes was the only interviewee for that scheme who felt that installation-related factors, including the advice given when specifying an installation, were influential. The installer's awareness of this influence was linked to the fact that he was himself part of the community and felt the responsibility of doing his job effectively, for community benefit, as well as embodying his personal and professional values in his work:

> *"I live in the town as well, so I see these people every day and I don't want to be doing anything which is going to be upsetting people. Very difficult. Because the way the Feed in Tariff is structured as well, and with the grant, it became so financially generous that it probably would allow an installation in a situation where it wouldn't be optimal but would still pay back quite generously. So I had to have that head on as well as my environmental head, thinking is this a good use of resources and taxpayers' money, with resources to make the panels? And also do I want to put my name to that?" [Adviser/Installer, Totnes]*

Advisers were observed applying limits to the advice they felt able to offer reflecting where they felt their advice to be legitimate. Some domains of energy consumption were also considered off limits. Discussing a recent long haul holiday provided a way of establishing rapport rather than a platform for introducing ideas of rebound effects. The design of the RENEW scheme and its performance measures meant that advisers in RE:NEW London focussed on ways to reduce energy bills (and release disposable income) rather than on resource reductions or carbon savings per se.

Some parts of a property might also be considered off limits. Advisers noted that they needed to be sensitive to where the householder gave them permission to go and there might be many reasons why areas of a home could not be assessed, which might be because a room was considered someone else's domain, or because the condition of the home was a source of some shame for the householder.

> *"You've got to sort of go with the flow of little bit. And in that one, for example, she didn't want me to go into her bedrooms to fit the radiator panels. I'm not quite sure why but I think it's just because they're full of junk and people get… I've been there, I'm a hoarder, I get a bit embarrassed about inviting people around sometimes." [Adviser/Installer, RE:NEW]*

Another theme extended the personal impact of the adviser into the impact of the experience during the advice visit or, more crucially, during retrofit installation. The WarmZone believed how he and his team presented themselves and how the householder would perceive the technology. For example, wearing overshoes into a property, appearing smart and in a clean company uniform, and acting quickly to rectify any mistakes or collateral damage were all seen as important in ensuring the householder felt positive about the technology. This adviser/installer was also more concerned with what could be termed the technology's 'compatibility', how much disruption would be caused by the insulation installation and what the adviser/installer could do to reassure the householder that this disruption would be minimal.

The impact of the adviser/installer also depends on the degree of technology maturity. This was particularly marked in the case of ASHPs where the technology was not well understood by the adopters. In these cases, the adviser/installer and installation attributes may be taken to be proxies for the attributes of the poorly-understood technology. The experience of the installation itself, the information provided by the adviser/installer on commissioning and the support available after installation when problems arise were all mentioned as extremely important. Those who were happy with the ASHP on cost or comfort grounds reported a very positive installation experience:

> *"Were we happy with his work? Well, yes we were. They were the cleanest people I've ever known...I mean, if they made a mess, all they did was hoover it up. With their own Hoover. They didn't use ours. No, as regards workmen, yes, they were brilliant." [Adopter, East Riding]*

> *"But the installation was very good. That's important...Well because they tidied up after them … and they were really, they were really very, very good. Each one of them. All I had to do was to make the tea and sandwiches. So yes I formed quite a nice relationship when they went." [Adopter, East Riding]*

The advisers/installers were aware of the uncertainties associated with a still-developing technology. And if the householder does not like or trust the installer, they will be less likely to adopt a technology. Where the householder feels installation has been more messy or disruptive than it should have been, they express dissatisfaction with the technology's performance. This was particularly noticeable with air source heat pumps where the correlation between poor installation or commissioning and dissatisfaction with the technology was mentioned in three out of seven installations across two case study areas. Those who reported a poor experience of installation either did not perceive any benefits from the new system, or they identified some more negative impacts of the technology (such as loss of storage space, noise impact on neighbours) alongside the benefits of increased comfort.

The final theme to emerge from these results was how an adviser/installer might influence the impact of their work though the commissioning process or aftercare. Aftercare is particularly problematic for micro-enterprises as there is usually no revenue stream attached to such activities, but the costs, of time, can be considerable. Adviser/installers also mentioned the role of other tradesmen who influenced the household. As an example, a device which turned an ordinary toilet flush into a dual flush is unfamiliar to many plumbers and one adviser/installer explained how he always left his mobile phone number so the householder could call him when, almost inevitably, their usual plumber wanted to remove the device.

Modifying an energy installation after use has also been observed, suggesting that as well as the disinterested user, there are other households who seek or have a level of expertise in managing their household technology and wish to be able to use it. A Finnish study of heat pump and wood pellet installations identified 192 types of modifications made by users in order to improve the compatibility of the installation with their specific home (Hyysalo et al., 2013). The desire to understand the technology being adopted was stated by, for example, a biomass adopter in the REcharge case study who, at the time of interview, was trialling a third boiler design after two previous boilers, from two separate manufacturers had failed to function effectively:

> *"I don't know anything about plumbing. Or boilers in particular. It's a bit of common sense really. And, well, I was going to say, I'm prepared to do what I can with the boiler. I mean, up to now it has been feeding it and taking ash out. But any little, anything I can do … really, I would like to be able to do any, to be able to do as much as I could. [Adopter, REcharge]*

While the themes described above all focus on the adviser/installer as an individual, other comments on the role of the adviser/installer illustrated important issues in the system in which the adviser or installer operated. All interviewees valued, or believed others to value, the advice offered on technology options through a council arms-length agency, with no sales or commission involved. However, when the installation contractor provided cost estimates for installations, several householders noted that these seemed higher than expected. They queried the value that the agency added to justify the management fee which was incorporated in these quotes.

Several adopters and non-adopters also suggested that they believed the advice and support should extend beyond the technical installation to other aspects such as securing planning permission if required and helping with registering for the Feed-in-Tariff. Across all technologies, adopters reported a mixed picture in terms of their experience with the installation companies. That is, there was a connection between their view of the council, their view of the adviser/installer, and their view of the effectiveness of the technology.

5.0 Discussion

The wider literature and the pilot stage of this research both suggested an important role for the adviser and installer in shaping the adoption and particularly the use of domestic energy technology. However, there is little theory which helps to analyse what shapes the adviser/installer's approach and impact. In the section below, we draw on the empirical evidence presented above to generate a typological framework that organises the adviser/installer attributes in a way that enables us to understand the impact and effectiveness of these advisers/installers more fully. Because the framework has been developed from empirical evidence, we do not suggest that this framework is comprehensive. Extending the scope of data collection to include pre-contact influences (such as website information provided, or visibility in the local community) would probably generate further elements for this framework.

First, two distinct aspects of adviser/installer capacity are identified. The technical capacity is the knowledge of the technology function and requirements which enables an adviser/installer to identify a technically feasible option. Alongside this, the adaptive capacity is the ability of the adviser/installer to assimilate contextual information in order to select the most appropriate solution from the range of technically feasible solutions. Second, two aspects of the adviser/installer's non-technical knowledge will affect whether their advice is heard and acted upon by the householder (or other trades). These are labelled as 'personal impact', to cover the non-technical skills that allow an adviser/installer to develop a rapport with their client, and 'motivation' which relates to the adviser/installer's own internal drivers that lead them to prioritise particular technologies with differing outcomes for their client. Third, we identify two aspects of the installation process as carried out by the installer. How the householder experiences the installation (as easy, or disruptive, or messy) appears to influence the householder's perception of the installed technology and therefore alters the householder's attitude towards that technology, which alters householder behaviour in using the installed technology. After installation, the process of commissioning and ongoing support to ensure that the householder assimilates the technology into their behaviour and routines as intended will also influence the outcomes from the adviser/installer's work. These aspects are distilled into the framework proposed in Table 3.

Table 3 about here

Aspects of installation which may have an influence on the adoption or use of energy technology are excluded from this framework if they fit into the categories of place, technology or user characteristics, as these categories are already covered by existing theory. For example, an evaluation of the UK's Low Carbon Building Programme (LCBP) identified that regional variation in take up of LCBP grants might be linked to the maturity of the supply chain in particular places

(Bergman and Jardine, 2009). Maturity of the local supply chain could be considered a place attribute, rather than an installer or installation attribute.

The six attributes proposed in the typological framework complement and add substance to suggestions that developing an "integrated offer" of physical and behavioural advice and measures will require new business models (Cre et al., 2012) which, in turn, is likely to require different competencies from the advisers and installers.

Some aspects of the typology are reinforced through other specific studies. The technical competence of the installer in installing the technology so that it runs as intended and fault-free is central to whether the technology has any chance of performing as the designer intended has been highlighted in a study of community-scale changes towards more sustainable living that identified "faulty systems are a major limiting factor in accepting that eco-systems are of benefit" (Hadfield-Hill, 2012). Technical competence, installing the selected technology so that it functions safely and effectively is the focus of accreditation in energy related fields (e.g. Microgeneration Certification Scheme, 2013; NICEIC, undated). However, the ability to select an appropriate technology is a precursor competence more difficult to assess. In problem solving for their clients, installers and advisers will operate rationally, but according to their own heuristics of risk and acceptability. What has been their particular experience with this kind of problem before? How have others in their networks solved similar problems? These questions are consistent with the findings from other recent socio-technical analysis of SME potential to contribute to low carbon retrofit (Killip, 2013). Another example of where the adviser/installer's *technical capacity* will constrain how they act as a mediator between products and the end user is where a joiner/carpenter's knowledge may dictate the type of windows which are specified in a renovation task. Here, if neither the adviser/installer nor the particular tradesmen's knowledge extends to the practicalities and availability of triple glazing, then it is unlikely that this energy efficiency technology will be installed (Risholt and Berker, 2013).

The need for adaptive capacity is also highlighted by a recent evaluation of the monetary savings and environmental benefits achieved through energy efficiency investment in UK households that found dwelling type, tenure, age of household, income but also energy prices and the state of repair of the house, all affected the benefits achieved (Tovar, 2012). These findings emphasise the need for a highly tailored approach, even within an area scheme where dwelling type, tenure or demography may not vary hugely.

Behaviours which establish a rapport and make potential adopters view technology in a positive light are more difficult to assess than technical competence, although the need for some 'client care' skills is noted in the UK professional standard relevant to low carbon retrofit work (BSI, 2012). We do not suggest that there are a unique set of adviser/installer behaviours which guarantee success; research on energy efficiency advisers in a range of European countries found that no single approach to building client rapport was guaranteed to be effective and that a range of types of interaction were deployed to influence householder energy use behaviour (Heiskanen et al., 2013).

'Installer motivation' and 'installation perception' have emerged from the analysis without being explicitly described by participants and these two factors in particular appear to be a novel contribution to understanding what affects the take up and use of domestic energy technology. Installer personal capacity and installation perception are distinct, as illustrated by this quote from an adopter who was unhappy with the quality of workmanship in installing her new heating system:

> "They were nice enough in their self. They were not ... at no stage were they unfriendly or rude or anything. It was just their standard of work which was very poor." [Adopter, East Riding]

These different installer/installation attributes are likely to have differing levels of influence at the different stages of the innovation diffusion chain of activity (Rogers, 2003): forming the intention to adopt, adoption and use. Using the example illustrated by the quotation above, the installer's personal impact was important in shaping the intention to adopt, but was over-ridden by the installation perception in shaping the adopter's perceptions and use of the technology.

The attribute of 'installer motivation' was linked by scheme managers to the installer capacity, particularly their adaptive capacity. If installers were interested in low carbon outcomes as well as saving energy bills then they would be more likely to gather information and advise on a solution tailored to that household's particular circumstances, combining cost reductions and energy consumption reductions. It is interesting to note that other research has found that even within cohorts of individuals with similar roles and similar institutional and policy contexts, installers' self-perception of impact varies, and correlates with their job satisfaction and their belief in their own expertise (Mahapatra et al., 2011). The ERYC scheme was designed to tackle fuel poverty in tandem with reducing carbon emissions (Owen et al., 2012). This primary focus led to advice being offered which reduced energy bills first, rather than ensuring emissions reductions, i.e. if mains gas was available, the scheme advisers would recommend conventional space heating by an efficient gas boiler rather than a renewable microgeneration technology.

6.0 Conclusions and policy implications

From a starting point that recognises that reducing climate changing emissions associated with residential property continues to be a significant challenge, this paper identifies a large and potentially highly influential group of actors who are currently excluded from the debates which influence policy development and effectiveness: the advisers and installers involved in the repair, maintenance and improvement of existing homes.

The empirical research findings reported in this paper indicate that advisers and installers play a powerful role in influencing both the adoption and use, and therefore impact, of domestic energy technology. The size of the market for renovation, maintenance and improvement work on homes undertaken by builders, plumbers, heating engineers and electricians is large and if all this activity contributed to low carbon retrofit the impact would be considerable. By focussing on the impact and behaviours of this group, we suggest a typological framework that, although it could doubtless be developed and refined, indicates novel routes for policy development and impact.

Because a major proportion of renovation, maintenance and improvement work is undertaken by micro-enterprises and these individuals are largely beyond the reach of current low carbon policy interventions. To help connect this framework and its potential contribution to effective policy development, it is worth considering the socio-technical context for the sole trader, micro enterprise or SME who could be involved in promoting, installing or maintaining low carbon energy equipment. Descriptions of this context might include the financially precarious and short work planning horizon of many of these businesses. This makes them risk averse because risk may poses immediate financial problems which they do not have the resilience to overcome. Adopting a new technology is easily seen as an avoidable risk. Policy measures promoting innovative technologies could de-risk adoption by, for example, covering any extra time involved in installation for the first few times a micro-enterprise deploys the technology. The building trades are also highly regulated through (in the UK) building control processes and tradesmen are both wary of proposing an innovative solution that building control will not approve, and also wary of further regulatory burden, such as certification might entail. This is not a new phenomenon; it was noted for exactly this group in 2000 (Banks, 2001). Staying with certification, because it is a key element of current policy through schemes such as the microgeneration certification scheme (MCS), policy could be designed to allow for one individual to carry certification, with its attendant costs and benefits for a wider group, recognising that these micro-enterprises already operate in networks of local, complementary skills and connections. These informal but often well-established networks allow the micro-enterprises to balancing of resource and capacity depending on current local market demand. Builders have also reported that they consciously navigate the relationship with the residential, price-sensitive customer to find a way to optimise technical solutions and costs (Killip, 2013).

These kinds of contextual factors mean that this group have priorities and motivations that do not align readily with policy priorities. For example, some micro-enterprises are motivated by stability of employment rather than growth and therefore they have little incentive to contribute to an agenda of economic growth. Equally, accreditation beyond health and safety requirements will be perceived by a tradesman who already had plenty of work as unnecessary bureaucracy or costs that add little value to the business. Understanding more of the drivers and priorities for this group, as suggested by the typological framework, would help policy makers to design interventions that harness the potential contribution of this sizeable and influential group towards achieving carbon reductions.

In the UK, there are some current areas of policy where an improved understanding of installers/advisers might be beneficial. The requirement for energy companies to ensure that smart meters are installed in all homes by 2020 (DECC, 2013) will generate a large number of home visits and installations which might act as trigger points for carbon reduction measures being specified and installed, if the smart meter installers have the capacity, skills and motivation to support them. The slow take up of the Green Deal since its launch in 2013 (DECC, 2014), with the scheme's heavy reliance on advisers delivering a service which householders are willing to pay for, even if the measures implemented have no immediate capital cost to them, suggests that simply creating the opportunity and expecting the adviser/installer sector to be able to catalyse a change in low carbon technology adoption is not enough.

Policy interventions are needed to provide incentives for the provision of lower carbon advice and solutions that match the installer's motivations for their work. The installers' own values and beliefs will shape the service they offer, and these values are not necessarily formed by low carbon policy and evidence. In particular, the need to offer clients 'value' and a 'good service' might be reconfigured, over time and with the right policy framework, to include low carbon considerations more fully.

The networks that shape micro-enterprise activity need consideration alongside the perspectives of individual practitioners. The sector has strong networks of custom and practice and the service they offer is dependent on their capacity to access different supply chains. These networks may have spatial, technical, supply chain, infrastructure, client or social elements. They may also provide a route to reach and influence individual practitioners where the dispersed nature of the trades makes finding effective communication channels difficult for policy makers. To unlock the potential of the advisers/installers in the mainstream RMI market, we need a better understanding of these networks and how they might change over time, as well as a better understanding of the individuals, in order to identify appropriate policy interventions. Understanding these networks might also help in replacing the ‘one-to-many’ channels usually deployed in disseminating policy, with more peer learning and social networks. The technology supply chain might be more amenable to policy influence, and broadening technology design considerations to include installer needs, as well as user needs, could be a fruitful avenue to explore.

Acknowledgements

This research was supported by a grant from the UK EPSRC Sustainable Urban Environment Programme. The authors are grateful to the anonymous reviewers whose comments improved the paper.

References

Ajzen, I., 1991. The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes 50, 179-211.

Banks, N., 2001. Socio-Technical Networks and the Sad Case of the Condensing Boiler, in: Bertoldi, P., Ricci, A., Almeida, A. (Eds.), Energy Efficiency in Household Appliances and Lighting. Springer Berlin Heidelberg, pp. 141-155

Bergman, N., Eyre, N., 2011. What role for microgeneration in a shift to a low carbon domestic energy sector in the UK? Energy Efficiency 4, 335-353.

Bergman, N., Jardine, C., 2009. Power from the People - Domestic Microgeneration and the Low Carbon Buildings Programme. Environmental Change Institute, Oxford.

Blake, J., 1999. Overcoming the 'value-action gap' in environmental policy: Tensions between national policy and local experience. Local Environment: The International Journal of Justice and Sustainability 4, 257 - 278.

BSI, 2012. PAS2030 Edition 2: Improving the energy efficiency of existing buildings. BSI London.

Caird, S., Roy, R., 2007. Consumer adoption and use of household energy efficiency products Design Innovation Group, Open University, Milton Keynes.

Caird, S., Roy, R., 2008. User-centred improvements to energy efficiency products and renewable energy systems: Research on household adoption and use. International Journal of Innovation Management 12, 327-355.

Caird, S., Roy, R., Herring, H., 2008. Improving the Energy Performance of UK Households. Results from surveys of consumer adoption and use of low and zero carbon technologies. Energy Efficiency 1, 149–166.

CCC, 2008. Building a low-carbon economy - The UK's contribution to tackling climate change. Committee on Climate Change, London.

Clegg, C.W., 2000. Sociotechnical principles for system design. Applied Ergonomics 31, 463-477.

Cre, J., Mlecnik, E., Kondratenko, I., Degraeve, P., Ven der Have, J.-A., Vrijders, J., Ven Dessel, J., Haavik, T., Aabrekk, S., Paiho, S., Stenlund, O., Svendsen, S., Vanhoutteghem, L., Hansen, S., 2012. Developing an integrated offer for Sustainable Renovations, Retrofit 2012, Salford.

DECC, 2011. UK Renewable Energy Roadmap. *http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx* [accessed 27 November 2012]

DECC, 2013. Smart Metering Implementation Programme, London.

DECC, 2014. Domestic Green Deal and Energy Company Obligation in Great Britain, Monthly report, April 2014, London.

Devine-Wright, P., 2007. Energy Citizenship: Psychological aspects of Evolution in Sustainable Energy Technologies, in: Murray, J. (Ed.), Governing technology for sustainability. Earthscan, London, pp. 63-86.

Dobbyn, J., Thomas, G., 2005. Seeing the light: The Impact of Microgeneration on the Way we Use Energy. SDC, London.

Energy Saving Trust, 2011. Trigger Points – a convenient truth. EST. London

Fielding, K.S., Spinks, A., Russell, S., McCrea, R., Stewart, R., Gardner, J., 2013. An experimental test of voluntary strategies to promote urban water demand management. Journal of Environmental Management 114, 343-351.

Fishbein, M., Ajzen, I., 1975. Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Addison-Wesley, Reading, MA.

Gillich, A., 2013. Grants versus Financing for Domestic Retrofits: A Case Study from Efficiency Maine. Sustainability 5, 2827-2839.

Greening, L.A., Greene, D.L., Difiglio, C., 2000. Energy efficiency and consumption - the rebound effect - a survey. Energy Policy 28, 389-401.

Hadfield-Hill, S.A., 2012. Living in a sustainable community: new spaces, new behaviours? Local Environment, 1-18.

Heiskanen, E., Johnson, M., Vadovics, E., 2013. Learning about and involving users in energy saving on the local level. Journal of Cleaner Production 48, 241-249.

Heiskanen, E., Lovio, R., Jalas, M., 2011. Path creation for sustainable consumption: promoting alternative heating systems in Finland. Journal of Cleaner Production 19, 1892-1900.

Hyysalo, S., Juntunen, J.K., Freeman, S., 2013. User innovation in sustainable home energy technologies. Energy Policy 55, 490-500.

Jaffe, A.B., Stavins, R.N., 1994. The energy paradox and the diffusion of conservation technology. Resource and Energy Economics 16, 91-122.

Jagger, N., Foxon, T., Gouldson, A., 2012. Skills constraints and the low carbon transition. Climate Policy 13, 43-57.

Killip, G., 2012. Beyond the Green Deal: Market Transformation for low carbon housing refurbishment in the UK, Retrofit, Salford.

Killip, G., 2013. Products, practices and processes: exploring the innovation potential for low-carbon housing refurbishment among small and medium-sized enterprises (SMEs) in the UK construction industry. Energy Policy 62, 522-530.

King, N., 2004. Using templates in the thematic analysis of text, in: Cassell, C., Symon, G. (Eds.), Essential Guide to Qualitative Methods in Organizational Research. Sage London, pp. 256-270.

Kirklees Council Environment Unit, 2011. Kirklees Warm Zone Scheme: End of Project Process Evaluation Report.

Kwan, C.L., 2012. Influence of local environmental, social, economic and political variables on the spatial distribution of residential solar PV arrays across the United States. Energy Policy 47, 332-344.

Lupton, R., Power, A., 2002. Social Exclusion and Neigbourhoods, in: Hills, J., LeGrand, J., Piachaud, D. (Eds.), Understanding Social Exclusion. OUP, Oxford, pp. 118-140.

Maby, C., 2009. Energy Advice in the UK - future needs and priorities. Severn Wye Energy Agency, Gloucester.

Maby, C., Bargaiola, F., Lepage, L., Egger, C., Ohlinger, C., Brokvist, E., Andre, E., Sijanec-Zavrl, M., Pandalieva, I., Claustre, R., Peyret-Rosa, A.-S., Mongredien, C., 2007. Energy advice in Europe 2007, a report from the SErENAdE partnership, p. 174.

Mahapatra, K., Nair, G., Gustavsson, L., 2011. Swedish energy advisers' perceptions regarding and suggestions for fulfilling homeowner expectations. Energy Policy 39, 4264-4273.

Maller, C., Horne, R., Dalton, T., 2012. Green Renovations: Intersections of Daily Routines, Housing Aspirations and Narratives of Environmental Sustainability. Housing, Theory & Society 29, 255-275.

Marechal, K., 2010. Not irrational but habitual: The importance of "behavioural lock-in" in energy consumption. Ecol. Econ. 69, 1104-1114.

McCullen, N.J., Rucklidge, A.M., Bale, C.S.E., Foxon, T.J., Gale, W.F., 2013. Multiparameter Models of Innovation Diffusion on Complex Networks. Siam Journal on Applied Dynamical Systems 12, 515-532.

McMichael, M., Shipworth, D., 2013. The value of social networks in the diffusion of energy-efficiency innovations in UK households. Energy Policy 53, 159–168.
Microgeneration Certification Scheme, 2013. About MCS, London. *http://www.microgenerationcertification.org/about-us/why-mcs* [accessed 27 August 2013]
Mirosa, M., Lawson, R., Gnoth, D., 2013. Linking Personal Values to Energy-Efficient Behaviors in the Home. Environment and Behavior 45, 455-475.
Nadel, S., 2012. The Rebound Effect: Large or Small? An ACEEE white paper. American Council for an Energy-Efficient Economy, Washington DC.
NICEIC, undated. NICEIC - What we do, Dunstable. *http://www.niceic.com/about-us/what-we-do* [accessed 27 August 2013]
Office for National Statistics, 2012. Construction statistics 2012, reporting on figures to the end of Q3 2011. , London.
Office for National Statistics, 2013. Labour Market Statistics Data Tables: JOBS04 spreadsheet, London.
Owen, A., 2013. Factors that affect the diffusion and impact of domestic 'green technology' and the role of 'place', School of Geography. University of Leeds, Leeds.
Owen, A., Mitchell, G., Unsworth, R., 2012. Reducing carbon, tackling fuel poverty: adoption and performance of air-source heat pumps in East Yorkshire, UK. Local Environment 18, 817-833.
Palmer, K., Walls, M., Gordon, H., Gerarden, T., 2013. Assessing the energy-efficiency information gap: results from a survey of home energy auditors. Energy Efficiency 6, 271-292.
Pester, S., Thorne, A., 2011. Photovoltaic systems on dwellings - key factors for successful installations. Building Research Establishment, Watford.
Platt, R., Cook, W., A, P., 2011. Green Streets, Strong Communities. IPPR, London.
Ravetz, J., 2008. State of the stock—What do we know about existing buildings and their future prospects? Energy Policy 36, 4462-4470.
Risholt, B., Berker, T., 2013. Success for energy efficient renovation of dwellings—Learning from private homeowners. Energy Policy 61, 1022-1030.
Rogers, E.M., 2003. Diffusion of Innovations, 5th ed. Free Press, New York.
Roy, R., Caird, S., Abelman, J., 2008. YIMBY Generation – yes in my back yard! UK householders pioneering microgeneration heat. The Energy Saving Trust, London, UK.
Roy, R., Caird, S., Potter, S., 2007. People centred Eco-design: consumer Adoption and Use of Low and Zero Carbon Products and systems, in: Murphy, J. (Ed.), Governing Technology for Sustainability. Earthscan, London.
Schäfer, M., Jaeger-erben, M., Bamberg, S., 2012. Life Events as Windows of Opportunity for Changing Towards Sustainable Consumption Patterns? Journal of Consumer Policy 35, 65-84.
SDC, 2006. Stock Take: Delivering improvements in existing housing. SDC, London.
Shove, E., 2009. How people use and 'misuse' buildings, in: ESRC/TSB (Ed.), ESRC Policy briefing. ESRC, Swindon, pp. 20-25.
Sorrell, S., 2007. The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency. UK Energy Research Centre, Surrey, UK.
Stern, P.C., 2000. Toward a coherent theory of environmentally significant behavior. J. Soc. Issues 56, 407-424.
Thorne, A., 2011a. Biomass Systems - key factors for successful installations. Building Research Establishment, Watford.
Thorne, A., 2011b. Ground Source Heat Pumps and Low Temperature Systems - key factors for successful installations. Building Research Establishment, Watford, p. 6.
Tovar, M.A., 2012. The structure of energy efficiency investment in the UK households and its average monetary and environmental savings. Energy Policy 50, 723-735.
Tuan, Y., 1990. Topophilia, Morningside ed. Columbia University Press, New York.

Waring, T., Wainwright, D., 2008. Issues and Challenges in the use of template analysis: two comparative case studies from the field The Electronic Journal of Business Research Methods 6, 85-94.

Figure 1:

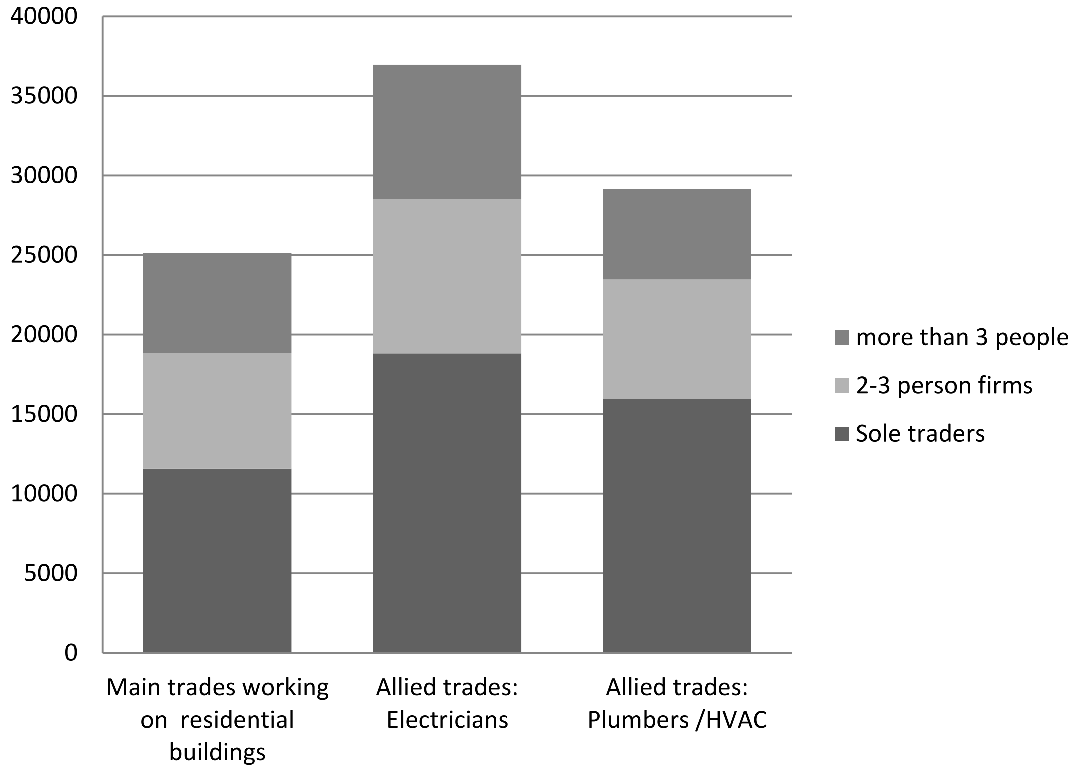

Figure 1: Firm size in UK residential construction industry (Office for National Statistics, 2012)

Reference

Office for National Statistics, 2012. Construction statistics 2012, reporting on figures to the end of Q3 2011. , London.

Table 1: Summary of Case Studies: Area-based schemes promoting domestic 'green' technology

Case study	Geographical context	Facilitator and delivery agent	Technology
Transition Streets Totnes (grant aided PV installation after households participated in a peer learning programme)	Totnes, a market town in South Devon, south west England, population approx. 8,000.	Community group contracted with local technical firm for technology installation	PV (after energy conservation training undertaken)
East Riding Affordable Warmth	Large rural county in northern England with extensive coastline	Local Authority and not for profit company	Air Source Heat Pumps
Kirklees WarmZone (energy conservation measures offered as a universal benefit)	Large local authority area comprising dense urban and rural areas. Diverse building stock	Initiated and supported by the Local Authority. Scheme was managed by Yorkshire Energy Services, a not for profit company established by the Council. All specification and installation was carried out by one contractor.	Loft and cavity wall insulation
Kirklees RE-Charge (offered an interest-free loan of up to £10,000, secured against the property and only repaid when the property was sold)	Large local authority area comprising dense urban and rural areas. Diverse building stock	Initiated and supported by the Local Authority. Installations by several local contractors were managed by Yorkshire Energy Services.	Microgeneration – including Solar thermal, solar PV, micro-hydro, biomass, air source heat pump
London RE:New – Hillingdon and Sutton	Homes within urban local authority areas. Targeted for the carbon reduction potential. Mixed building stock.	Local Authority through Managing Agents (two different NGOs/not for profits)	Energy conservation and water conservation measures (e.g. draught proofing, low flow shower heads) plus some behavioural advice.

Table 2: Summary of interviewees

	Scheme Managers	Installers / Advisers	Adopters	Non-adopters	Total
RE: NEW London	4	2	2	-	8
WarmZone Kirklees	2	1	-	-	3
Transition Streets Totnes	1	1	6	4	12
RECharge Kirklees	2	2	8	5	17
ERYC ASHPs	3	2	6	-	11
Innovators	-	-	3	-	3
Total	12	8	25	9	

Table 3. A framework to describe the impacts of installers/installation on the diffusion and use of domestic energy technology

Proposed Sub-category	Description	Effect and mode of impact
Installer capacity - technical	Knowledge of the technology function and requirements; skills in specifying, designing and installing effective domestic energy technology.	Sets the technical effectiveness of proposed solutions i.e. the maximum potential benefits from energy technology adoption.
Installer capacity - adaptive	How well does the installer gather information about the situation in which technology will be deployed and tailor design and advice to a specific situation?	Enhances the compatibility of the energy technology for the adopter.
Installer personal impact	The social skills and communication abilities that enable the installer to work effectively with adopters. Demonstrating respect for people's homes.	Influencing the potential adopter's attitudes towards technology and, by association, the pro-environmental behaviours and outcomes that the technology can enable.
Installer motivation	Why does the installer advise, design and install? What outcomes to they hope to see from their work?	Sets priorities in design and commissioning. Sets parameters for self-limiting impact.
Installation perception	Was installation a positive or negative event from the householder's viewpoint? This includes physical impacts and disruption, information sharing and interactions with the adviser or installer.	Affects householder's perception of the technology and, by association, their perception of the impact of the technology.
Installation aftercare	What is the result of the commissioning process? Is there any knowledge transfer or capacity building for the householder? What maintenance and check-ups are required?	Does the adopter understand how they can affect the technology's function? Ensures impact of the technology by checking it is functioning as intended and repairing or upgrading as required.