

Towards the Tees Valley Energy Transition – Residential Decarbonisation and Skills Analysis

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Abstract: guided by the theory of planned behaviour, we conducted an interview study to identify beliefs that potentially influence social-housing residents' future behaviour with domestic low-carbon technology in retrofit housing. The study included (group interview n=6, individual interviews n=14). Behavioural beliefs, normative beliefs and control beliefs were identified from participants' answers using the theory of planned behaviour and thematic analysis. For successful implementation, it will be important to ensure that the predominant benefits (positive beliefs) emerging from this study are implemented (e.g., lower heating bills) and the barriers (negative beliefs) are avoided or alleviated (e.g., upfront costs). The results will be quantified in a follow-up, survey study.

Keywords: low-carbon technology, theory of planned behaviour, heat pump, solar panels, battery energy storage system

1. Introduction

One of the measures to alleviate the effects of global warming currently under consideration is residential decarbonisation. Technical solutions (heat pump, solar panel, battery energy storage systems) are available, but initiatives that do not consider residents' acceptance will not be successful. Psychological theories and models such as the theory of planned behaviour and the technology acceptance model [1] provide tools that allow us to qualitatively identify beliefs that guide human behaviour with technology [2] and quantitatively predict behaviour [3]. The aim of the current study is therefore to identify beliefs that potentially guide social-housing residents' future behaviour with domestic low-carbon technology. The objectives are to identify behavioural beliefs (a person's subjective probability that performing a behaviour of interest will lead to a certain outcome or provide a certain experience), normative beliefs (injunctive normative belief: the expectation or subjective probability that a given referent individual or group approves or disapproves of performing the behaviour under consideration; descriptive normative belief, belief as to whether important others themselves perform the

behaviour) and control beliefs (about the presence of factors that can facilitate or impede performance of the behaviour) that may underly residents' behaviour with domestic low-carbon technology according to the theory of planned behaviour [1], as well as any other beliefs.

2. Methodology and Theory

Participants. Twenty participants were recruited via two methods: email and social media. Potential participants could either respond to a dedicated email address or complete an online form, both of which were monitored for responses collected; participants were subsequently contacted by email or phone. All were offered either an online interview via VoIP or a face-to-face interview in their own home. The twenty participants (6 in a group interview and 14 in individual interviews) consisted of tenants, a mixture of men (10) and women (9), with an age range from 26-75. All residents lived in the Tees Valley in the north-east of England.

Group interview. Before the questions (see Table 1), the participants listened to a short presentation on global warming and UK climate change targets. It was explained how low-carbon homes, a critical part of the UK's efforts, are to meet climate change. At the start of the interview, participants were further presented with still images and a short video of a model retrofit home with explanatory live commentary, that demonstrated how a low-carbon technology home would look. The walkthrough video was created by Teesside University's School of Computing, Engineering and Digital Technologies using Autodesk REVIT, 3D modelling software.

Semi-structured questions with open answers (see Table 1), based on the theory of planned behaviour, were used to encourage discussion of ideas. The theory of planned behaviour is appropriate to use in this research, as the theory accounts for beliefs that guide human behaviour (behavioural beliefs, normative beliefs and control beliefs) [1] and has been used to qualitatively understand [2] and quantitatively predict [3] people's use of technology. In this study, the benefits of conducting a group interview were to ensure the questions were understood and the other tools used, i.e., video, were effective for purpose [4]. As the Interview guide or questions are the main tool for providing consistency in the generation of qualitative data and, consequently, the conclusion of the research [6], this group interview was carried out as a pre-cursor to individual interviews.

Individual interviews. The procedure was adapted from the group interview. The participants were shown the pre-recorded presentation, including the content of both group interview presentations; then followed a short testimonial, from a tenant with low-carbon technology already installed. (The decision to include this testimonial was made following the results from the group interview where 'lived experience' of tenants currently using low-carbon technology was a high priority for potential acceptance). The interview questions (Table 1) were then asked.

The interviews were conducted and transcribed verbatim by five researchers. In order to avoid preconceptions and bias, three researchers analysed the data from the interviews, checking results against one another to come to a final agreement; this increased the credibility and trustworthiness of the results.

Table 1. Interview questions guided by Theory of Planned Behaviour (TPB)

TPB belief	Questions	
Behavioural Beliefs	Advantages	<ul style="list-style-type: none"> • What do you see as the advantages of you living in and using a low-carbon technology home? • What positive feelings do you associate with you living in and using a low-carbon technology home?
	Disadvantages	<ul style="list-style-type: none"> • What do you see as the disadvantages of you living in and using a low-carbon technology home? • What negative feelings do you associate with you living in and using a low-carbon technology home?
Normative Beliefs	Approval	<ul style="list-style-type: none"> • Please tell me about the individuals or groups who would approve or think you should live in and use a low-carbon technology home.
	Adopters	<ul style="list-style-type: none"> • Please tell me about the individuals or groups who are most likely to live in and use a low-carbon technology home.
	Disapproval	<ul style="list-style-type: none"> • Please tell me about the individuals or groups who would disapprove or think you should not live in and use a low-carbon technology home.
	Non-adopters	<ul style="list-style-type: none"> • Please tell me about the individuals or groups who are least likely to live in and use a low-carbon technology home.
Control Beliefs	Drivers	<ul style="list-style-type: none"> • Please tell me about any factors or circumstances that would make it easy or enable you to live in and use a low-carbon technology home.
	Barriers	<ul style="list-style-type: none"> • Please tell me about any factors or circumstances that would make it difficult or prevent you from living in and using a low-carbon technology home.

Data Analysis.

Thematic analysis [7] was applied to the data sets and deductive coding began with the theory of planned behaviour belief questions on low-carbon homes to identify the broad, overarching emergent themes. Iterative coding included searching the data for relationships, similarities and differences and beginning to organise these into themes. Within the coding and themes, comparisons, frequency and elaborations were considered for determinants of behaviour and specific emerging themes [7]. The three researchers compared and reached a consensus on the codes and themes included in the results, and another researcher checked these for clarity

3. Results and Discussion

Group interview. Four themes identified were unique to the group interview: participants expressed the desire to experience how the heat pump system would look and work inside their own home when installed. As lived experience of residents currently using the technology was a high priority for them, a testimonial was suggested. This feedback was incorporated into the individual face-to-face interviews and proved effective as these specific themes did not arise in this cohort. Participants expressed their wish to have choice in which, if any, low-carbon technologies they would like installed – this may be due tenants fearing increased rent as a result. The questions of noise from the system and possible vandalism were also raised. The participants discussed the issue of skills gaps within the energy sector and suggested upskilling of current staff - this was seen as an opportunity to create new opportunities and jobs (Table 2). *Individual interviews.* Control beliefs, behavioural beliefs, normative beliefs and other themes were identified (Table 3). *Control Beliefs:* environmental and climate change benefits were cited by almost all participants as the main motivator along with the benefits of lower running costs. Upfront costs were viewed as a barrier for five participants, but this was mostly likely from the point of view of self-funding the system. Retrofitting was viewed as a motivator, providing insulation was sufficient for effectiveness of the system. Further information regarding fitting the systems into multi-occupancy building or flats would improve motivation.

Behavioural Beliefs: lower running costs were cited by almost all participants as a huge benefit; only two participants expressed concern around cost: environmental benefits were viewed alongside this, as a major advantage. Solar energy was regarded positively and as a free energy source. Temperature regulation was seen as an advantage, especially if it could be controlled and included the ability to provide zoned heating. Loss of storage space in the home was mentioned, along with the issue of maintenance. A few participants were concerned with technology flaws – these fears could be reduced by providing further information and engaging with tenants. *Normative Beliefs:* most participants believed that nobody would disapprove of or refuse the opportunity to live in a low-carbon home. Other themes: political – the issues surrounding renewables and the environment were viewed as complex, with confusing and conflicting information given to the public, but regardless of this most people were willing to engage in environmentally friendly initiatives. It was felt that a national plan is required, which includes low-carbon housing. Some participants felt that they did not have enough information to decide on whether low-carbon technology would function correctly or be suitable within their home

4. Conclusion

Based on our findings, housing association tenants may benefit from clear, transparent information (e.g. from others who have experience of living in a low-carbon home) and support throughout the whole process, before, during and after fitting of low-carbon technologies. Specifically, they may profit from information about the benefits (e.g. improved health) and facilitators (e.g. potential savings on running costs) of changing to a low-carbon home. They may also benefit from information about the potential disadvantages (e.g. any flaws in the technology) and barriers (e.g. pre-requisites such as good home insulation), and explain how these can be overcome and dispel any that are not true. Successful interaction between the new energy technology and the individual [5] could be encouraged by including different audiences and social groups and to consider individuals, while making efforts to adapt to their reality.

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Table 2. Group interview results.

Belief categories	Belief topics
Control Beliefs	Energy/running costs Retrofit versus new build installation Ability to control the system
Normative Beliefs	Realism of representation (of a low-carbon home) Evidence of system effectiveness from current users Who should live in a low-carbon home – variety of answers but lack of information on the system prevented further hypothesising
Behavioural Beliefs	Environmental Benefits Resistance to low carbon home Tenants' choice for installation
Other Themes	Noise, tamperproof system Skills Gap

Table 3: Individual-interview results

Control Beliefs (Barriers & motivators)	Behavioural Beliefs (Advantages & Disadvantages)	Normative Beliefs (Important Referents)	Other Themes (Beyond TPB)
<p>Environmentally friendly/Save the planet (13) "Well, it'll benefit climate change. You know, because I'm not burning fossil fuels." [P2]</p> <p>Running Costs - See Behavioural Beliefs Motivator: "So there's the basic cost list and that it would cost less definitely" [P6] Barrier: Cost Concerns (3)</p> <p>Multi-occupancy building/flats (3) Barrier: "I don't know how it would work with the set up in my ground floor flat" [P8]</p> <p>Initial up-front costs (5) Barrier: "So, not discounting things like climate change and things like that, from an economic point of view, and being a lease owner, it's not a financially viable project for me." [P2] Motivator: "Would cost you £10,000 to buy it, you save £50,000 in a lifetime, that's worth it." [P14]</p> <p>Retrofitting versus new build (3) Barrier: I can't help thinking that as a retrofit to this property it wouldn't work without other things being done. [P1]</p>	<p>Running costs (13) Advantage: "Well it's going to be cheaper fuel, that's a big factors isn't it" [P9] Disadvantage (3) "My concerns are cost" [P2]</p> <p>Environmentally friendly/Save the planet – See Control Beliefs "I think I can help me to warm more ecological and reduce my carbon emission and all that." [P7]</p> <p>Using solar energy (6) "the easy one would be solar panels, because it's a long building and it's an East West building, and we've got ample room on the roof for solar panels" [P5]</p> <p>Temperature Regulation (7) Advantages: "Well, they'd be warmer. They'd just run constantly. Don't have to mess about with the thermostat or anything like that. They'd be set with the weather." [P12] Disadvantages: "I just don't want to have my bedroom heated or anything. Can it be switched off from there?" [P9]</p> <p>Technology flaws (4) "I suppose the problem would be with any batteries wouldn't it, cause all</p>	<p>Who would approve of/live in a low-carbon home</p> <p>People who can afford it (1)</p> <p>Younger People (4)</p> <p>People on low income (3)</p> <p>Environmentally Conscious (4)</p> <p>Big Families (4)</p> <p>Those who see other people with it (3)</p> <p>Councils, Social Housing Provider and the Government (3)</p> <p>Who would disapprove of/not live in a low-carbon home</p> <p>No-one would disapprove (9)</p> <p>Older People (4)</p>	<p>Politics (5) "We all can help the planet and help our pockets by doing something or speaking about it. The more we yell at the government the more they will think they've got to do this." [P14]</p> <p>Further information on low-carbon technology and instructions on use (7) "I think there would be really interested, it would be positive impact on them and possibly they didn't know anything about it, because I didn't know anything about it until I went to [organisation's] open day. These retrofits, I've never heard of it before, so yeah, I think that would be a positive note" [P3]</p> <p>Social housing/Income inequalities (4) "Others do not have the same luxury "The only negative feeling is that I've I wish everybody else was having this system so they wouldn't have to, you know, families with kids, wouldn't have to worry about their cost of keeping themselves warm when it comes to winter." [P4]</p>

<p>Motivator: "Maybe upgrading the properties and as they're doing that, installing it." [P12] Disruption (2) "[M]y main concern is the upheaval" [P3] Insulation (5) "There would have to be a lot of insulation to the home before the low carbon side of it would work" [P1]</p>	<p>the all the rest is nice and sufficient." [P11] Loss of storage space (1) "you'd lose a bit of wall space, perhaps with the size of the radiators, but I would say none [disadvantages] that you couldn't overcome very readily." [P1] Maintenance (2) "So when it comes to maintenance of systems like this it might be might be a bit long and costly but that's it really." [P4]</p>	<p>Current rise in energy prices (3) "We run entirely on electric, so we're all feeling the pinch, but even more so if you're just running on electric for your heating" [P3]</p>
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