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Do Psychological Factors Relate to Energy Saving Behaviours in Inefficient and Damp Homes? A study among English social housing residents

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Abstract

Social housing residents are vulnerable to rising energy costs. Reductions in energy use through behaviour change may be part of the solution but require an insight into the factors that relate to energy saving behaviour in this context. This paper responds to recent calls for an integrated approach to studying energy saving behaviours, investigating psychological (i.e. attitudes; perceived behavioural control; subjective norms), contextual (i.e. dwelling energy efficiency; problems with condensation, damp and mould), and socio-demographic factors (i.e. gender; age) together. Data was collected using a cross-sectional survey among social housing residents in South-West England. Dwelling characteristics were not found to add to explaining heating related and other energy saving behaviours beyond well-known psychological and socio-demographic factors. The results did suggest that the presence of condensation, damp and mould was associated with more frequent heating-related energy saving behaviours, but not other energy saving behaviours. Furthermore, a moderation effect was found whereby subjective norms appeared to relate more strongly to heating-related energy saving behaviours when people live in energy efficient homes. The study illustrates the value of an integrated approach in understanding the complex interactions between contextual factors, psychological factors and energy saving behaviour and offers opportunities for future research.

Keywords: Social Housing; Behaviour; Energy Saving; Dwelling Characteristics

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1. Introduction

The demand for social housing is rising (UN, 2015), new social housing programmes are starting in a number of countries and the number of households on waiting lists across Europe is increasing (Pittini et al., 2015). This sector of housing offers subsidised rent for people on a low-income and social housing residents tend to be under constant financial pressure (DCLG, 2016, Tunstall et al., 2013). Fuel poverty, also referred to as energy poverty, is an especially pressing problem in the social housing sector (UN, 2015). Almost 25% of low-income households in Europe are unable to keep their home adequately warm (Pittini et al., 2015), and, in the UK, fuel poverty affects approximately one in ten households living in social housing (DECC, 2015). Fuel poor households struggle to keep their homes comfortably warm as a result of a combination of factors (e.g. low household income; high energy costs; poor energy efficiency of the home; Atanasiu, Kontonasiou & Mariottini, 2014). Consequently, many low-income households also experience damp and cold conditions at home, as they cannot afford to heat their home comfortably and adequately in winter (Boomsma et al., 2017; Hills, 2012; Liddell, 2008). In recent years, energy efficiency of the social housing stock has improved (UN, 2015), but many housing problems (e.g. cold housing, damp, mould, condensation) tend to be more common among social housing tenants than among owner-occupiers (Pevalin, Taylor & Todd, 2008). Thus social housing residents are especially vulnerable to rising energy costs, but the sector is often overlooked when it comes to the research on residential energy use (Langevin, Gurian & Wen, 2013; Pivo, 2014).

Reductions in energy use through energy efficiency improvements and behaviour change have been identified by some researchers as an opportunity to reduce financial concerns and improve housing conditions for social housing residents (Hamilton et al., 2016; Hamilton et al., 2013; Hong et al., 2009; Lopes, Antunes & Martins, 2012). Previous research outside the social housing sector has emphasised that addressing the behavioural dimension of domestic energy use in particular offers the potential for significant energy savings in the short term (Dietz et al., 2009). In fact, occupant behaviour is thought to be one of the reasons why a building's energy use can be up to 40% above expectations (Yu et al., 2011). Technical solutions alone may not be effective in reducing energy consumption, especially if they are not embedded in people's daily behaviour and energy understanding (Abrahamse et al., 2005; Midden, Kaiser & McCalley, 2007; Steg, 2008). Strenuous efforts are now underway, notably by the International Energy Agency, to define and quantify occupant behaviour from the technical/engineering perspective (see https://www.annex66.org/), and, in an important complementary effort, from a behavioural/societal perspective (see http://www.ieadsm.org/task/task-24-phase-2/).

To encourage energy saving behaviour (ESB) specifically in the social housing sector we need to examine the factors that relate to the energy behaviours which households currently engage in. Increasing our understanding of the drivers and barriers to behaviour can aid in designing more effective energy conservation measures (Steg & Vlek, 2009). When referring to energy saving behaviours in this paper we refer to everyday curtailment actions, or "everyday actions in energy use that require either no or minimal structural adjustment" (Barr, Gilg & Ford, 2005, p. 1426). A distinction is often made between contextual and psychological factors, or objective and subjective factors, when examining determinants of energy saving behaviours (Martinsson, Lundqvist, & Sundström, 2011; Thøgersen & Grønhøj, 2010). Psychological factors are diverse and can represent, amongst others, individual beliefs and perceptions. Contextual

factors are also a heterogeneous category and can include physical-structural conditions (e.g. dwelling characteristics), socio-demographic characteristics, cultural and economic aspects (Thøgersen & Grønhøj, 2010; Von Grabe, 2016). While traditional environmental psychological approaches to studying ESB tend to focus on the individual, contextual influences on behaviour receive less attention (Lopes et al., 2012). Calls have been made for a more integrated approach, investigating psychological and contextual factors together, to account for the complexity of household energy use characterised by different contextual influences, decision types and psychological variables (Steg & Vlek, 2009; Wilson & Dowlatabadi, 2007). According to Stephenson et al. (2010), cognitive factors (e.g. beliefs and understandings), the material culture (e.g. technologies and buildings), and energy practices (e.g. activities and processes) all underlie consumer energy behaviour and are highly interactive. Studying these different components together in diverse contexts may open up opportunities to modify energy behaviours more effectively (Stephenson et al., 2010). Specifically, there is a need to bring together engineering and social sciences to tackle the complexity of energy saving behaviours, and start to move away from a fragmented, disciplinary approach (Lopes et al., 2012). Thus, attention needs to be focused on studying energy-related behaviours at the intersection point between these two sciences (Pellegrino & Musy, 2017). Literature on the factors that relate to energy saving behaviours in low-income households is especially limited (Chen, Xu & Day, 2017). In a step towards this integrated approach, the current paper brings together social science literature on the theory of planned behaviour (i.e. attitudes, perceived behavioural control, subjective norms) with the building engineering literature on energy efficiency and condensation, damp and mould problems (together: CDM problems), and literature from both fields on socio-demographics (i.e. gender and age), specifically in the context of energy saving behaviour in social housing residents. The focus on these two dwelling characteristics follows from the prevalence of fuel poverty and associated CDM problems in the social housing sector. Using data from a cross-sectional survey, the current research examines the extent to which these dwelling characteristics add to explaining energy saving behaviours beyond well-known psychological and socio-demographic factors. The research will also build on and add to previous studies and models that have started to explore the complex interactions between psychological and contextual factors in the context of energy saving behaviours.

Specifically, the literature suggests that psychological factors can lead to behaviour change when certain contextual variables provide incentives or disincentives (Guagnano, Stern & Dietz, 1995). For instance, environmental concerns may only lead to reduced car use if alternative modes of transport are available (Steg & Vlek, 2009). In a similar vein, contextual factors may shape opportunities and constraints for energy use (Abrahamse & Steg, 2009). This puts forward a potential moderating role (Steg & Vlek, 2009) of dwelling characteristics upon the relationship between psychological factors and energy behaviours. Stated differently, this paper will examine whether the relationship between psychological variables from the theory of planned behaviour and energy saving behaviour depends on a dwelling's energy efficiency level and the presence of condensation, damp and/or mould problems.

Before further outlining the specific research questions, this paper provides a short literature review discussing previous research from the social science and building research literature on selected relevant psychological and contextual factors and their link to energy behaviours. Then the results of a cross-sectional survey among social housing residents are presented and discussed.

1.2. Psychological Factors: Attitudes, Perceived Control and Subjective Norms

Many psychological factors influence energy (saving) behaviours, and it is not within the scope of this paper to provide a conclusive list. Instead, the paper focuses on one of the most commonly used theories in the environmental psychological domain (Klöckner, 2013): the theory of planned behaviour (TPB; Ajzen, 1985). As the aim of this paper is to investigate the role of specific dwelling characteristics relative to psychological and socio-demographic variables, this commonly used psychological theory was selected as a starting point. The TPB has received strong empirical support for explaining a variety of pro-environmental behaviours (Klöckner, 2013). In a study on energy conservation intentions in low-income households, TPB variables were found to explain almost half of the variance in intentions (Chen et al., 2017). In fact, the study showed that the predictive power of socio-demographics (i.e. age, gender, household size and house ownership) and other contextual factors (i.e. climate zones) disappeared when TPB variables, as well as other psychological variables, were added to the model. Chen and colleagues (2017) state that this finding highlights the importance of considering the psychological variables involved in energy saving behaviours.

The TPB is a general model of deliberate behaviour (Klöckner, 2013) and suggests that behaviour follows an intention to engage in specific behaviour. These intentions in turn depend on attitudes towards the behaviour, perceived behavioural control, and subjective norms related to the behaviour. Attitudes can be defined as "the extent to which engaging in the behaviour is evaluated as positively or negatively" (Steg & Nordlund, 2013, p. 186). In the aforementioned study on low-income households (Chen et al., 2017), attitudes towards energy saving were found to be the strongest predictor of energy conservation intentions. Other studies have also identified a link between environmental (Barr et al., 2005) and energy conservation (Abrahamse & Steg, 2009) attitudes and energy saving behaviour. However, research by Martinsson et al. (2011) seems to suggest that for self-reported energy saving behaviour, environmental attitudes might a better predictor in high-income households compared to low-income households.

Perceived behavioural control reflects the "perceived possibility to perform the behaviour" (Steg & Nordlund, 2013, p. 187). Due to the invisibility of energy, individuals tend to find it difficult to perceive a clear relationship between their behaviour and household energy use (Thøgersen & Grønhøj, 2010). As a result, individuals may feel that they do not have control over the energy use in their home. This sense of helplessness with regards to energy consumption can provide a barrier to engaging in energy saving behaviour (Sweeney et al., 2013). Furthermore, a feeling of perceived behavioural control, or self-efficacy has been identified as having a strong influence on energy saving behaviour (Abrahamse & Steg, 2009; Thøgersen & Grønhøj, 2010). If people feel they can take action to reduce their energy consumption they feel more committed to engaging in energy saving behaviour, and are more likely to do so (Thøgersen & Grønhøj, 2010).

Finally, subjective norms are described as "the extent to which a person believes that important others would approve or disapprove of the behaviour" (Steg & Nordlund, 2013, p. 186). Through observing and interacting with others, people form beliefs on the acceptable energy behaviours in the household (Aarts & Dijksterhuis, 2003). If people who share the same house have dissimilar ideas on energy use, this can lead to conflict and frustration and present a barrier to engaging in energy saving behaviours (Sweeney et al., 2013). In fact, research has shown that subjective norms help determine personal beliefs around the positive outcomes of saving energy (Thørgersen & Grønhøj, 2010). Support for the relationship between subjective norms and energy saving behaviour is mixed, and it has been suggested that certain conditions need to be in place for subjective norms to have an effect (Dixon et al., 2015). For instance, when looking at intentions to conserve energy, subjective norms have been found to relate more strongly to

intentions if environmental concern is low (Bamberg, 2003) and group identification is high (Terry & Hogg, 1996; Terry, Hogg & White, 1999).

1.3. Contextual Factors: Dwelling Characteristics

As stated at the start of this introduction, low energy efficiency levels may contribute to fuel poverty (Antanasiu et al., 2014), and, in turn, fuel poor households have a higher likelihood of experiencing CDM problems (Pevalin et al., 2008). But the question remains whether these dwelling characteristics are also associated with energy (saving) behaviours. Energy efficiency and CDM problems are part of the 'material culture' as defined by Stephenson et al. (2010). These are not intrinsic to the person, nonetheless these dwelling characteristics may also characterise energy saving behaviour in the home. With regards to energy efficiency, much previous research has been undertaken on the relationship between the energy performance rating of a dwelling and its actual energy consumption – rather than energy saving behaviours. These studies tend to demonstrate that more efficient dwellings on paper also consume less energy in reality (Hirst & Goeltz, 1985; Caldera, Corgnati & Filippi, 2008), compared to less efficient dwellings. However, it should be noted that wide variations in energy use can be observed between identical homes and a gap between predicted and actual energy use exists: commonly referred to as the 'energy performance gap' (Branco et al., 2004; De Wilde, 2014; Guerra-Santin et al., 2017; Haas, Auer & Biermayr, 1998). With regards to this gap, Yan et al. (2015) note that variations between predicted and actual energy use show that it is the occupant of the building, not the design of the building, that drives its energy use. Even though, the reduction in energy consumption in more efficient dwellings is often primarily attributed to technical aspects (i.e. increased insulation and airtightness and more efficient heating and ventilation systems), much less is known about the contribution of the occupants' energy saving behaviours. Some studies have actually reported a 'rebound' or 'take-back' effect (Galvin, 2014; Hong et al., 2006; Jones et al., 2016), whereby dwelling occupants engage in fewer energy saving behaviours in energy-efficient, new-build or refurbished homes (e.g. choose higher thermostat settings and use longer heating periods). This may occur because occupants prefer to increase their thermal comfort rather than reduce their home energy use. This effect may be stronger in the social housing sector as the occupants have low or fixed incomes and may therefore currently choose to operate their homes at lower internal temperatures at the expense of their thermal comfort.

Only limited empirical research exists on the relationship between CDM problems and energy saving behaviours. The need for a comfortable home has been identified as both a barrier (Sweeney et al., 2013), as well as a motivating factor to engage in energy saving behaviours (McMakin, Malone & Lundgren, 2002). With regards to the former, it is evident that CDM problems may present a barrier to people taking heating-related energy saving actions (e.g. reducing thermostat setting and heating duration). In fact, occupants of dwellings subject to these issues may need to increase their heating and cooling set points and periods to remedy the problems they are experiencing. It could be expected that people living in homes with CDM problems are also likely to be more cautious about taking energy saving behaviours, if they believe that it may further exacerbate the housing problem. Thus for some households, a paradox exists between on one hand, taking energy saving actions and on the other, experiencing CDM problems. When dealing with a limited household budget, one way around this paradox is to engage in other types of energy saving behaviours (e.g. appliance-related such as turning appliances/lights off when not needed) to save money which can be used on heating the home. This may explain why the need for a comfortable home can also be a motivating factor to engage in energy saving behaviours. For low-income households at least, it has been found that the need

for comfort relates more strongly to energy conservation intentions compared to concerns around the environmental impact of energy consumption and preventing waste (Chen et al., 2017).

1.4. Contextual Factors: Socio-Demographics

A number of studies have investigated the relationships between socio-demographic variables and energy saving behaviours. This section discusses two factors which tend to be consistently included in these studies: gender and age. With regards to gender and energy saving behaviour studies suggest that women tend to be more concerned about energy use and are more likely to save energy compared to men (Barr et al., 2005; Carlsson-Kanyama & Lindén, 2007; Kollmuss & Agyeman, 2002). However, some evidence suggests that this relationship depends on the specific energy behaviours that are being measured and the specific context. In a European study across four countries, men were found to consume more direct and indirect energy compared to women, but this difference was largest in the transport sector and smaller for household energy use (Räty & Carlsson-Kanyama, 2010). Also, in an organisation setting males were found to have stronger intentions to conserve energy compared to females (Chen & Knight, 2014).

Research on the effect of age on energy saving behaviour is also somewhat mixed. Households with older residents tend to engage in more energy saving behaviours (Barr et al., 2005). Older households often own fewer household appliances compared to younger households, and less energy is consumed when using these appliances due to a difference in usage (for instance by turning them off when not in use; Carlsson-Kanyama & Lindén, 2007; Jones & Lomas, 2016). However, there is also research to suggest that older households use more energy compared to younger households when it comes to heating, as they tend to prefer a higher ambient temperature, partly due to health reasons (Black, Stern & Elworth, 1985; Wei, Jones & de Wilde, 2014). At the same time, qualitative research has shown that older people on low incomes (a group prevalent in the social housing sector) often struggle to afford keeping warm at home and cope by adjusting their heating behaviour. For instance, they may adjust the length of time for which their home is heated or only heating part of the home, or by wearing warm clothes indoors or going to bed early to keep warm while keeping the heating off or low (Chard & Walker, 2016).

1.5. Current Study

Research on the factors associated with energy saving behaviours often examines either psychological or contextual factors, rather than using a combined approach (Steg, 2008). This study aims to explore both factors, examining psychological motivators following the TPB framework (attitudes, perceived behavioural control and subjective norms) and dwelling characteristics especially relevant in a social housing context (dwelling energy efficiency, CDM problems) as well as socio-demographics (gender and age). This study used data from a "Social Housing Survey" conducted among social housing residents in a city in South-West England in 2015. The survey was part of a larger field study aimed at designing a 'serious game' on energy use for social housing residents (for more information see: www.energaware.eu). The full survey included measures on energy related issues in the home, perceptions and behaviours related to energy use at home, use of digital devices and social networks, and demographics and household characteristics. Data from this larger survey is used to address the research questions set out in this paper; we only focus on the variables relevant to the current paper. The survey was conducted at the start of the field study, before any intervention took place.

The following research questions were examined:

RQ1: *What energy-related attitudes, perceptions and behaviours do social housing residents report?*

RQ2: *Do dwelling characteristics add to explaining energy saving behaviours beyond the influence of socio-demographics and psychological factors?*

RQ3: *Does the influence of psychological factors on energy saving behaviours depend on dwelling characteristics? So, is the influence of attitudes, perceived behavioural control and subjective norms on energy saving behaviours enhanced or constrained by the energy efficiency of the dwelling and the presence of housing problems (condensation, damp and/or mould)? See Figure 1 for an illustration of this proposed moderation effect.*

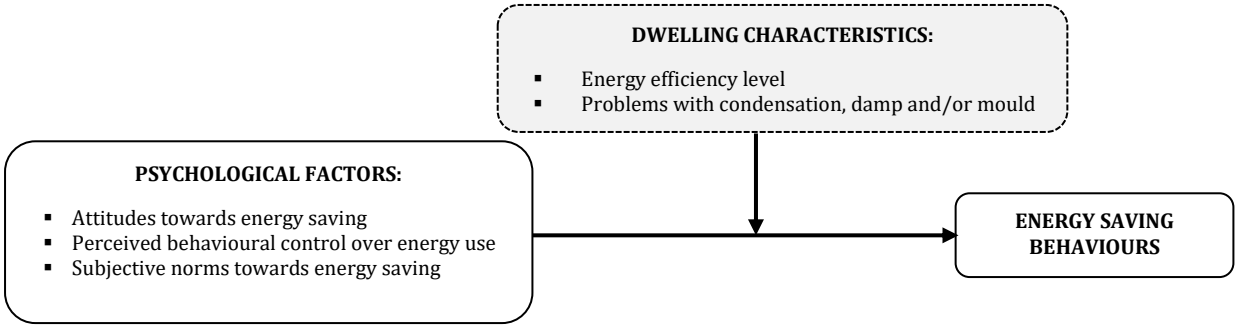

Figure 1. Proposed moderation effect of dwelling characteristics upon the relationship between psychological factors and energy saving behaviours (RQ3).

2. Material and Methods

2.1. Participants and Procedure

A paper-based survey was sent out to 2,772 social housing residents in a city in South-West England, along with a letter and flyer about the project which also informed residents about the option to fill in the survey online. To encourage households to complete the survey, a prize draw was used as an incentive. In total, 536 (33 online) of the households completed the survey, giving an overall response rate of 19.3%. Respondents had a mean age of 58 (ranging between 18 and 96), most householders who responded to the survey fell in the 55-64 (18%) or 65-74 (18%) age category**;** 10% of respondents did not report their age. Out of the 536 householders who responded to the survey, 37% were male, 56% were female, and 7% did not provide their gender.

2.2. Measures

2.2.1. Dwelling characteristics. To assess the *energy efficiency performance* of the dwelling in which respondents resided, SAP (Standard Assessment Procedure) scores were used. The SAP assessment was undertaken by accredited Domestic Energy Assessors and were provided by the social housing provider. SAP is the UK government's national calculation methodology for the energy efficiency assessment of domestic buildings and is used to check compliance with building regulations in England and Wales for new (Part L1A) and existing buildings (Part L1B). It is also the methodology used for delivering the EU Energy Performance of Buildings Directive (European Parliament, 2003) and is used to produce energy performance certificates (Kelly, Crawford-Brown & Pollitt, 2012). SAP scores range between 1 and 100, the

higher the rating the better the energy efficiency performance of the dwelling. Scores were available for 390 of the participating households, with an average SAP score of *M* = 60.40 (*SD* = 19.59). To assess *CDM problems* respondents were asked whether they had any problems with condensation, damp or mould in their home. Just under half of respondents answered 'yes' to this question (41.8%), a small majority answered 'no' (54.9%), and the remaining 3.36% (*N* = 18) did not provide an answer to this question.

2.2.2. Socio-demographics. Respondents were asked to report their age and gender (see Section 2.1.).

2.2.3. Psychological factors. *Attitudes towards energy saving* were measured with two items: I often think about how I could save energy; I am prepared to save energy with the right support. Both items were rated on a 5-point scale (ranging from 1: Strongly agree to 5: Strongly disagree). A mean score was calculated for these two items, the reliability for this combined scale was sufficient (Cronbach's α = .64). A high score reflects a negative attitude towards saving energy. *Perceived behavioural control* and *subjective norms* were measured with the following statements, respectively: I have control over how much energy is consumed in my home; My friends and family say it's important to save energy. Both items were rated on the same response scale as the attitude scale, so high scores reflect low control and weak norms, respectively.

2.2.4. Self-reported energy saving behaviours (ESB). Respondents were asked to rate twenty-three *energy saving behaviours* on a 5-point scale, using the labels 1: always, 2: often, 3: sometimes, 4: very occasionally, 5: never (similar to scales used in Gatersleben, Steg & Vlek, 2002; Matthies et al., 2011; Thøgersen & Grønhøj, 2010). One item was removed because only a small number of participants (*N* = 81) had responded to this question ("I only use my dishwasher when it is full"). Nine items were included to measure heating-related ESB (e.g. "I make sure that the curtains/blinds are closed when the heating is on in the evening"; "I turn off the heating in rooms that are not normally used"), and thirteen items were included to measure other ESB, including appliance-related ESB (e.g. "I shut down my computer when it is not in use"). It is relevant to examine heating-related ESB separately from other ESB as the dwelling characteristics assessed in this research mainly refer to energy efficiency, which is especially important for heating the home.

Mean scores for both subscales were computed, and reliability of the subscales was found to be sufficient (Heating-related ESB, 9 items, Cronbach's α = .66; Other ESB, 13 items, Cronbach's α = .80). High scores reflect infrequent behaviours. The items belonging to each subscale can be found in Table 1.

2.3. Data Analysis

All items included in the study had a 'don't know' and/or 'not applicable' response option. These responses were excluded from the data analysis, unless explicitly stated otherwise. In addition, some respondents did not provide answers to all the items in the survey, or data was not available for all households in case of the SAP scores. As a result the number of valid cases for each analysis varies; the available sample size for each analysis is indicated in the results.

2.3.1. Regression and moderation analysis. To answer Research Question 1, mean scores and correlations were calculated. To answer Research Question 2, a hierarchical multiple regression was conducted (see Section 3.2). In hierarchical multiple regression a dependent variable is predicted from more than one independent variable (predictors). The predictors were entered into the model in blocks starting with the known predictors from previous research, in this case: socio-demographics and TPB variables, followed by the new predictors, in this case: dwelling characteristics (Field, 2014). The change in R^2 (i.e. the amount of variance in the

outcome explained by the model), after adding dwelling characteristics to the model will indicate whether the addition of the new predictors significantly adds to explaining energy saving behaviours.

To answer Research Question 3 a series of moderation analyses were conducted using the PROCESS macro (Hayes, 2013). Moderation examines the combined effect of two variables on another (Field, 2014); in this case: the interaction between dwelling characteristics and TPB variables upon energy saving behaviours. In the moderation analyses reported in Section 3.3 the outcome (i.e. energy saving behaviours) was predicted from the predictor variable (i.e. TPB variables), proposed moderator (i.e. dwelling characteristics) and interaction of the two (i.e. TPB variables X dwelling characteristics). Only the latter effect is reported in the results as moderation is found when this interaction effect is significant. Follow-up analysis in the form of simple slopes analysis provides insight into the nature of the moderation effect (Field, 2014). In simple slopes analysis regression equations were plotted for energy saving behaviours predicted from TPB variables, for: 1) the average value of dwelling characteristics, 2) one standard deviation above the mean value of dwelling characteristics and, 3) one standard deviation below the mean value of dwelling characteristics. By comparing the significance, values and directions of these slopes it can be inferred whether the relationship between TPB variables and energy saving behaviours changes at different levels of dwelling characteristics.

3. Results

3.1. RQ1; What Energy-Related Attitudes, Perceptions and Behaviours do Social Housing Residents Report?

As can be seen in Table 1, participants reported doing a number of ESB relatively frequently, on a scale ranging from 1 (always) to 5 (never) Mean scores were below midpoint (i.e. rated always/often on average) for all behaviours except "I tell other people to do things that save energy". The frequency of heating-related ESB was similar to the frequency of other ESB, $t(177) = 0.88$, $p = .380$, $d = .06$.

Participants reported quite positive attitudes towards saving energy ($M = 2.06$, $SD = 0.85$), this mean score was significantly different from the scale midpoint (3), $t(439) = -23.07$, $p<.001$, $d = 1.10$. Furthermore, mean scores indicate that participants tended to agree that they have control over how much energy is consumed in their home ($M = 2.32$, $SD = 1.12$), and that their friends and family say it's important to save energy ($M = 2.19$, $SD = 1.00$). Both scores were significantly different from the scale midpoint (3), $t(475) = -13.24$, $p<.001$, $d = 0.61$; $t(469) = -17.67$, $p <.001$, $d = 0.81$, respectively.

Correlations were examined as a first step to exploring the relationships between socio-demographics, psychological factors, dwelling characteristics and ESB (see Table 2). There was no significant relationship between the socio-demographics measured in this study (age; gender) and ESB. Age was related to perceived behavioural control, with older respondents perceiving more control over the energy consumed in their home. In addition, older respondents were less likely to report CDM problems than were younger respondents, while females were more likely to report CDM problems than were males.

Looking at the psychological factors, subjective norms had the strongest relationship with ESB: strong subjective norms were related to more frequent heating-related and other ESB. Respondents with more positive attitudes towards energy saving tended to also report more frequent other ESB, while no significant relationship was found with heating-related ESB. Furthermore, subjective norms and attitudes were (strongly) related: respondents who reported strong subjective norms also tended to report positive attitudes towards energy saving. Perceived

behavioural control was not found to relate to either heating-related or other ESB. The only variable that was found to relate to perceived behavioural control was the presence of CDM problems. Respondents who reported experiencing CDM problems were somewhat more likely to disagree with the statement that they had control over the energy consumed in their home.

The energy efficiency level of the dwelling, measured as the SAP score, was not found to relate to either heating-related or other ESB. CDM problems also did not relate to heating-related or other ESB.

Table 1
Items included in the ESB subscales with mean scores and number of responses

Item	Mean (SD)	N
Heating-related ESB	1.95 (0.62)	353
I make sure that the curtains/blinds are closed when the heating is on in the evening.	1.67 (1.05)	511
I make sure that the curtains are open when the sun is shining in winter.	1.38 (0.80)	513
I make sure that the windows are closed when the heating is on.	1.33 (0.69)	520
I change the temperature on my thermostat.	2.26 (1.34)	438
I adjust the temperature on my radiators.	2.78 (1.49)	459
When no one is at home the heating is off.	1.57 (1.07)	497
I wear very warm clothes in winter so I can keep the heating on low or off.	1.90 (1.14)	513
I turn off the heating in rooms that are not normally used.	2.14 (1.49)	469
I close the doors between rooms.	2.40 (1.45)	503
Other ESB	1.92 (0.61)	218
I try to minimise my shower time to 5 minutes.	2.52 (1.47)	461
I make sure that no appliances are left on standby.	2.35 (1.41)	505
I make sure that chargers are unplugged when not in use.	1.91 (1.32)	505
I shut down my computer when it is not in use.	1.54 (1.04)	357
I only boil the water I need in the kettle.	1.65 (0.97)	516
I make sure that I use the right sized hob ring for each pan when cooking.	1.45 (0.83)	504
I make sure that the fridge and freezer doors are not open for longer than necessary	1.18 (0.54)	520
When I am the last to leave a room I turn the lights off.	1.20 (0.59)	517
When I buy a new appliance I look carefully at the energy labels.	2.12 (1.32)	491
I only use my washing machine when I have a full load of washing.	1.55 (0.88)	466
When I am the last to leave a room I turn off the appliances that are on.	1.63 (1.02)	510
I use energy saving modes on my appliances.	2.29 (1.33)	388
I tell other people to do things that save energy	3.08 (1.50)	432

Table 2

Correlations between dependent variables and predictors.

	Heating-related ESB (low score = more frequent ESB)	Other ESB (low score = more frequent ESB)	Age	Gender	Attitudes	Perceived behavioural control	Subjective norms	SAP score
Age	r = -.04 p = .479 N = 324	r = -.10 p = .163 N = 207						
Gender (0 = male, 1 = female)	r = -.11 p = .053 N = 339	r -.06 p = .400 N = 213	r = -.09 p = .070 N = 472					
Attitudes (low score = positive attitudes)	r = .07 p = .236 N = 305	r = .21 p = .002 N = 203	r = .04 p = .379 N = 405	r = .06 p = .234 N = 418				
Perceived behavioural control (low score = high control)	r = .10 p = .087 N = 320	r = .04 p = .568 N = 208	r = -.10 p = .047 N = 431	r = -.03 p = .473 N = 447	r = -.01 p = .830 N = 424			
Subjective norms (low score = strong norms)	r = .12 p = .039 N = 324	r = .31 p<.001 N = 207	r = -.05 p = .273 N = 430	r = .03 p = .485 N = 443	r = .36 p<.001 N = 417	r = .04 p = .375 N = 438		
SAP Score (high score = energy efficient)	r = <.01 p = .951 N = 251	r = -.05 p = .525 N = 139	r = -.08 p = .118 N = 351	r < .01 p = .999 N = 359	r = -.01 p = .935 N = 305	r = .02 p = .742 N = 340	r = -.01 p = .883 N = 336	
CDM problems (0 = yes, 1 = no)	r = .06 p = .311 N = 342	r = .11 p = .096 N = 213	r = .31 p<.001 N = 469	r = -.10 p = .028 N = 480	r = .05 p = .350 N = 426	r = -.09 p = .050 N = 461	r = -.04 p = .370 N = 454	r = .09 p = .092 N = 377

In sum, participants reported relatively frequent ESB, both heating-related as well as other ESB. Furthermore, positive attitudes towards energy conservation, strong subjective norms and perceived behavioural control over energy use were reported. Strong subjective norms were related to heating-related ESB, while positive attitudes toward energy saving and subjective norms were found to relate to other ESB. Amongst the predictors the strongest relationships were found between: 1) positive attitudes and strong subjective norms, and 2) the presence of CDM problems and younger age.

3.2. RQ2: Do Dwelling Characteristics add to Explaining ESB Beyond the Influence of Socio-Demographics and Psychological Factors?

A hierarchical regression analysis (see Section 2.3) was conducted to investigate the relationships between the predictors and heating-related and other ESB in more detail. Table 3 summarises the results of the regression analysis for heating-related ESB.

Table 3

Linear model of predictors of heating-related energy saving behaviours (N = 172), with 95% bias corrected and accelerated confidence intervals reported in parentheses. Confidence intervals and standard errors based on 1000 bootstrap samples.

	B	SE B	β	Sig.
Step 1				
Constant	2.02 (1.52; 2.52)	0.25		.001
Age	-0.00 (-0.01; 0.01)	0.00	-.04	.620
Gender (0 = male, 1 = female)	-0.13 (-0.32; 0.05)	0.09	-.11	.168
Attitudes (low score = positive attitudes)	0.04 (-0.07; 0.16)	0.06	.06	.442
Perceived behavioural control (low score = high control)	-0.00 (-0.08; 0.08)	0.04	.00	.988
Subjective norm (low score = strong norm)	0.02 (-0.08; 0.12)	0.05	.03	.724
Step 2				
Constant	2.00 (1.40; 2.59)	0.30		.001
Age	-0.00 (-0.01; 0.00)	0.00	-.09	.266
Gender (0 = male, 1 = female)	-0.11 (-0.29; 0.07)	0.09	-.09	.236
Attitudes (low score = positive attitudes)	0.03(-0.08; 0.15)	0.06	.05	.583
Perceived behavioural control (low score = high control)	-0.00 (-0.08; 0.08)	0.04	-.00	.966
Subjective norm (low score = strong norm)	0.03 (-0.07; 0.13)	0.05	.05	.576
SAP score (high score = energy efficient)	0.00 (-0.01; 0.01)	0.00	.01	.904
CDM problems (0 = yes, 1 = no)	0.22 (0.03; 0.41)	0.10	.19	.023

Note: R^2 = .02 for Step 1; R^2 = .05 for Step 2 (p = .072). Dependent variable: heating-related energy saving behaviours, response scale 1(Always) – 5(Never).

As stated, dwelling characteristics were added in step 2 of the model. This did not significantly increase the variance explained by the model (p = .072). As can be seen in Table 3, only CDM problems were identified as a significant predictor in the model. The beta (β) value shows that the presence of CDM problems was associated with more frequent heating-related ESB. However, the overall predicted variance of the model is low (5%), and the full model was not found to be significantly better at predicting heating-related ESB compared to using the mean as a 'best guess' (F(7,171) = 1.19, p = .312).

Table 4 summarises the results of the regression analysis for other ESB. Adding dwelling characteristics to the model did not significantly increase the variance explained by the model (p = .233). Attitudes were identified as a significant predictor in the model; positive attitudes were related to more frequent other ESB. Although the overall predicted variance of the model is relatively low (13%), the full model was found to be slightly better at predicting other ESB compared to using the mean as a 'best guess', $F(7,110) = 2.10$, p = .050.

Table 4

Linear model of predictors of other energy saving behaviours (N = 111), with 95% bias corrected and accelerated confidence intervals reported in parentheses. Confidence intervals and standard errors based on 1000 bootstrap samples.

	B	SE B	β	Sig.
Step 1				
Constant	1.41 (0.81; 2.01)	0.30		.001
Age	0.00 (-0.01; 0.01)	0.00	.03	.719
Gender (0 = male, 1 = female)	-0.08 (-0.29; 0.14)	0.11	-.07	.491
Attitudes (low score = positive attitudes)	0.15 (0.00; 0.30)	0.07	.21	.045
Perceived behavioural control (low score = high control)	-0.02 (-0.10; 0.07)	0.04	-.03	.726
Subjective norm (low score = strong norm)	0.09 (-0.03; 0.20)	0.06	.15	.142
Step 2				
Constant	1.57 (0.83; 2.30)	0.37		.001
Age	-0.00 (-0.01; 0.01)	0.00	-.02	.840
Gender (0 = male, 1 = female)	-0.06 (-0.27; 0.16)	0.11	-.05	.618
Attitudes (low score = positive attitudes)	0.15 (0.00; 0.30)	0.07	.21	.046
Perceived behavioural control (low score = high control)	-0.00 (-0.09; 0.08)	0.04	-.01	.929
Subjective norm (low score = strong norm)	0.08 (-0.03; 0.20)	0.06	.14	.157
SAP score (high score = energy efficient)	-0.00 (-0.01; 0.00)	0.00	-.08	.412
CDM problems (0 = yes, 1 = no)	0.17 (-0.05; 0.39)	0.11	.15	.128

Note: R^2 = .10 for Step 1; R^2 = .13 for Step 2 (p = .233). Dependent variable: difficult energy saving behaviours, response scale 1(Always) – 5(Never).

3.3. RQ3: Does the Influence of Psychological Factors on ESB Depend on Dwelling Characteristics?

To examine the potential interaction between psychological factors and dwelling characteristics a series of moderation analyses (see Section 2.3) were conducted. As can be seen in Table 5, the relationships between attitudes and perceived behavioural control on the one hand, and heating-related and other ESB on the other hand, were not influenced by SAP scores and the presence of CDM problems. So, whether attitudes or perceived behavioural control were related to the frequency of ESB did not depend on the energy efficiency of the dwelling, or on whether respondents experienced CDM problems. For subjective norms, no significant interaction was found with CDM problems, however a potentially interesting pattern was found for the SAP scores. The interaction between subjective norms and SAP scores was significant for heating-related ESB (p = .034), however the confidence interval does indicate that this effect is quite weak.

Table 5

Interaction effects between psychological factors and building characteristics for heating-related ESB and other ESB

	Interaction effect	Moderation analysis	N
Heating-related ESB	Attitude x Energy Efficiency (SAP)	*b* = -0.00, 95% CI [-0.01; 0.01], *t* = -0.04, *p* = .967	*N* = 209
	Attitude x CDM problems	*b* = 0.05, 95% CI [-0.12; 0.22], *t* = 0.59, *p* = .558	*N* = 296
	Perceived behavioural control x Energy Efficiency (SAP)	*b* = -0.00, 95% CI [-0.01; 0.01], *t* = -1.50, *p* = .135	*N* = 224
	Perceived behavioural control x CDM problems	*b* = 0.04, 95% CI [-0.10; 0.17], *t* = 0.55, *p* = .581	*N* = 310
	Subjective norm x Energy Efficiency (SAP)	*b* = 0.01, 95% CI [0.00; 0.01], *t* = 2.13, *p* = .034	*N* = 226
	Subjective norm x CDM problems	*b* = 0.02, 95% CI [-0.11; 0.15], *t* = 0.32, *p* = .751	*N* = 313
Other ESB	Attitude x Energy Efficiency (SAP)	*b* = 0.00, 95% CI [-0.00; 0.01], *t* = 0.54, *p* = .592	*N* = 127
	Attitude x CDM problems	*b* = 0.09, 95% CI [-0.17; 0.34], *t* = 0.69, *p* = .492	*N* = 199
	Perceived behavioural control x Energy Efficiency (SAP)	*b* = 0.00, 95% CI [-0.00; 0.01], *t* = 1.56, *p* = .121	*N* = 130
	Perceived behavioural control x CDM problems	*b* = -0.06, 95% CI [-0.21; 0.10], *t* = -0.71, *p* = .480	*N* = 203
	Subjective norm x Energy Efficiency (SAP)	*b* = 0.01, 95% CI [-0.00; 0.01], *t* = 1.52, *p* = .132	*N* = 131
	Subjective norm x CDM problems	*b* = 0.04, 95% CI [-0.14; 0.22], *t* = 0.39, *p* = .696	*N* = 202

A simple slopes analysis (see Table 6) revealed that for high SAP scores there was a significant positive relationship between subjective norms and heating-related ESB. This means that in this case, as illustrated in Figure 2, strong subjective norms were associated with frequent heating-related ESB, while weak subjective norms were associated with less frequent heating-related ESB. On the other hand, for low and average SAP scores no significant association was found between subjective norms and heating-related ESB. Thus, subjective norms only related to heating-related ESB if respondents lived in an energy efficient home.

The interaction between subjective norms and SAP scores for other ESB was not significant (*p* = .132), but based on the findings for heating-related ESB an exploratory simple slopes analysis was also conducted for this interaction. A significant relationship between subjective norms and other ESB was found for average and high SAP scores, but not for low SAP scores. So, strong subjective norms related to slightly more frequent other ESB, but only if respondents lived in a high or average energy efficient home (see Figure 2). It should be emphasized that although the simple slopes analysis revealed significant effects, the overall interaction effect was not significant so the pattern described here is weak. The pattern does however open up opportunities for future research which will be elaborated upon in the Discussion.

Figure 2. Simple slopes equations of the regression for subjective norms as a predictor of heating-related (left) and other (right) ESB at different levels of SAP scores.

Table 6

Simple slope analysis: regression for subjective norms as a predictor of heating-related and other ESB for low, mean and high SAP scores

Regression for subjective norms as a predictor of behaviour		Simple slope analysis
Heating-related ESB (*N* = 226)	Low SAP	*b* = -0.06, 95% CI [-0.87; 0.07], *t* = -0.87, *p* = .385
	Mean SAP	*b* = 0.04, 95% CI [-0.03; 0.12], *t* = 1.16, *p* = .246
	High SAP	*b* = 0.14, 95% CI [0.04; 0.25], *t* = 2.63, *p* = .009
Other ESB (*N* = 131)	Low SAP	*b* = 0.07, 95% CI [-0.09; 0.23], *t* = 0.81, *p* = .417
	Mean SAP	*b* = 0.15, 95% CI [0.04; 0.27], *t* = 2.62, *p* = .010
	High SAP	*b* = 0.23, 95% CI [0.08; 0.38], *t* = 2.93, *p* = .004

4. Discussion

Energy-related behaviour is embedded in everyday actions and needs (Fischer, 2008), and is determined by many contextual and psychological influences (Steg, 2008; Steg, Perlaviciute & van der Werff, 2015; Thøgersen & Grønhøj, 2010; Von Grabe, 2016). This study explored energy saving behaviours amongst social housing residents, a context where fuel poverty and associated housing problems as well as financial pressures are commonplace. The aim of this study was to examine to what extent dwelling characteristics can add to explaining energy saving behaviour in this context, beyond previously supported psychological and socio-demographic factors. In addition, a potential moderation effect was explored, whereby dwelling characteristics could

influence the relationship between psychological factors and energy saving behaviours. Based on the building literature, the dwelling characteristics that formed the basis of this study were energy efficiency levels and problems with condensation, damp and mould. From the social science literature the theory of planned behaviour was used to select the psychological factors (i.e. attitudes; perceived behavioural control; subjective norm) explored in this research.

4.1. Interpretation of the Findings

First of all, the energy-related attitudes, perceptions and behaviours of social housing residents were explored (*RQ1*). The results indicated that this particular sample of social housing residents were quite engaged with energy saving. They reported a number of frequent energy saving behaviours, which included both heating-related as well as other energy saving behaviours. Attitudes towards energy saving were positive, and respondents felt they had at least some control over the energy use in their home, and that their friends and family found it was important to save energy (i.e. strong subjective norms). Initial correlations suggested that psychological factors (i.e. strong subjective norms and positive attitudes) were more strongly related to heating-related and other energy saving behaviours, compared to socio-demographics and dwelling characteristics.

These relationships were further explored using regression analysis in order to answer *RQ2: do dwelling characteristics add to explaining energy saving behaviours beyond the influence of socio-demographics and psychological factors?* With regards to heating-related energy saving behaviours adding dwelling characteristics to a model including socio-demographics and psychological factors did not significantly increase the amount of variance explained by the model. CDM problems were identified as a significant predictor; the presence of CDM problems was associated with more frequent heating-related energy saving behaviours. From the limited literature on the relationship between CDM problems and energy behaviours we may expect low-income households who experience CDM problems to engage in other types of energy saving behaviours to save money in order to heat their home (as explained in Section 1.3 of the Introduction). But these results suggest that the experience of CDM problems could also relate to heating-related energy saving behaviours. More research is needed in this area but one possibility is that financial concerns are an underlying factor for this relationship. Householders who cannot afford to keep their home comfortably warm often live in cold homes, which are associated with condensation, damp and mould issues (Boomsma et al., 2017; Hills, 2012; Liddell, 2008). The same financial struggles which make it difficult to afford heating bills could also prompt households to conserve energy. Overall, the regression model for heating-related energy saving behaviours was not found to be significant, only a small amount of variance (5%) could be explained by the predictors. We will go into this further after discussing the results for the regression model for other energy saving behaviours.

With regards to other energy saving behaviours adding dwelling characteristics to a model including socio-demographics and psychological factors also did not significantly increase the amount of variance explained by the model. Attitudes towards energy saving were identified a significant predictor; that is, positive attitudes towards energy saving were found to relate to more frequent other energy saving behavours. Moreover, the regression model was significant and total explained variance (13%) was somewhat higher compared to the model for heating-related energy saving behaviours. It should be noted that the explained variance for both models was similar to previous studies that have attempted to explain household energy use, or self-reported energy saving behaviours using TPB. Abrahamse and Steg (2011) found that TPB variables explained 5% of variance in household energy use measured through meter readings.

More recently, Dixon et al. (2015) found that the TPB explained 45% of the variance in energy conservation intentions and only 6% of the variance in self-reported energy behaviours. So, the TPB may be better at explaining intentions to reduce energy use rather than (self-reported) energy saving behaviours (Abrahamse & Steg, 2011). Similarly, dwelling characteristics may relate differently to (self-reported) energy saving behaviours and conservation intentions. Furthermore, the TPB has been criticised for not considering the role of moral norms in environmental behaviour and is limited in predicting habits and repeated behaviours (Klöckner, 2013). The latter aspect is especially important to consider here as some, or even many, energy related behaviours could be considered habitual. Habits can be defined as "learned sequences of acts that have become automatic responses to specific cues, and are functional in obtaining certain goals or end-states" (Verplanken & Aarts, 1999. p. 104). Some of the behaviours that respondents indicated as doing 'always' in the current study may well be habits, which could also explain why the variance explained by the current model was low.

In sum, the factors included in this study were only able to explain a small amount of the variance in energy saving behaviours. There is tentative support that dwelling characteristics can add to explaining heating-related energy saving behaviours, next to socio-demographics and psychological factors. But dwelling characteristics were unable to explain other energy saving behaviours beyond the variance explained by socio-demographics and psychological factors.

Finally, moderation analyses were conducted to examine *RQ3: does the influence of psychological factors on energy saving behaviours depend on dwelling characteristics?* This research question followed from literature into the relationship between psychological and contextual factors in explaining pro-environmental behaviour. According to this literature (Guagnano et al., 1995; Steg & Vlek, 2009), psychological factors can lead to behaviour change when certain contextual factors provide incentives or disincentives. The current research examined whether the relationships between attitudes, perceived behavioural control and subjective norms on the one hand, and energy saving behaviours on the other hand, depended on the dwelling's energy efficiency level and presence of CDM problems. Or, coming back to the title of this paper: do psychological factors relate to energy saving behaviours in inefficient and damp homes? In this case, no support for a moderation effect of dwelling characteristics was found. So, whether respondents lived in an efficient or inefficient home, and whether they experienced CDM problems or not, did not affect the relationship between psychological factors and energy saving behaviours – with one exception that calls for further examination. For heating-related energy saving behaviours a significant interaction between subjective norms and energy efficiency was found. The results suggest that strong subjective norms were only related to more frequent heating-related energy saving behaviours if respondents lived in an energy efficient home. For respondents who lived in a home with a low energy efficiency level, subjective norms were not associated with difficult energy saving behaviours. For other energy saving behaviours some support for a similar trend was found. This is an intriguing effect and warrants further research into this topic. It is also in line with previous research which has suggested that the relationship between subjective norms and energy behaviours depends on certain conditions being in place (Dixon et al., 2015). So far, these studies have mainly looked at social or psychological conditions (e.g. level of environmental concern or group identification), but this result emphasises that the effect of subjective norm may also depend on material conditions.

4.2. Limitations and Future Research

A few points need to be taken into account when interpreting the results. Firstly, most of the variables included in this study were measured using only one item. This is because the survey

needed to be kept as short as possible to encourage many householders to respond. There is mixed support for single-item measures (Bergkvist & Rossiter, 2007; Gardner et al., 1998), but this issue is difficult to overcome in field studies such as these – still these limitations need to be acknowledged. Moreover, the data in this study is based on self-reported, not actual or observed, energy saving behaviour. Research has shown that there can be high agreement between stated and actual behaviour (Whitehead, 2005), and measures of self-reported energy behaviour are commonly used in the social science field. But there are limitations as well, responses may have been influenced by social desirability bias and could reflect to some extent what respondents wished they were doing or were willing to do (Martinsson et al., 2011). Furthermore, with regards to the measures included in this study it is also important to note that previous research has assessed attitudes towards energy saving with items that follow more directly from the definition of attitudes reported in Section 1.2, compared to the items included in this paper. For the current research, we reasoned that being prepared to save energy and often thinking about this behaviour is indicative of a positive evaluation of energy saving behaviour. But it can also be argued that attitudes should be operationalized as evaluative statements that follow more directly from its definition (e.g. "energy saving is not very enjoyable"; cf. Abrahamse & Steg, 2011).

Secondly, this was a cross-sectional study, descriptive of one point in time, so the direction of the effects needs to be carefully interpreted. The findings can only be interpreted as factors associated with energy saving behaviour, rather than influencing or determining energy saving behaviour. The latter can only be assessed using an experimental or longitudinal design. The term 'predictor' is used in the context of the regression analysis, but this does not imply causality.

Thirdly, certain contextual and psychological factors were included in the study, but there are of course many other factors that could be considered. As noted by Thøgersen and Grønhøj (2010) "electricity consumption is purely 'derived demand' integrated in practically all activities in a modern household" (p.7740). Therefore, there are numerous relevant contextual and psychological influences on energy saving behaviour and it is not within the scope of this paper to account for all of them. The aim of this study was to focus on dwelling characteristics thought to be especially relevant in the social housing context, and to make a comparison with socio-demographic and psychological variables that are commonly studied. The theory of planned behaviour fit the requirements for this study, but we acknowledge that this theory is somewhat limited in explaining (self-reported) energy behaviours. As stated by Abrahamse and Steg (2011), a more comprehensive set of psychological variables is needed to explain this complex construct more effectively. For instance, based on the potential interaction between subjective norms and energy efficiency, future research could consider not only examining subjective norms (also referred to as injunctive norms: the extent to which behaviour is commonly approved/disapproved), but also descriptive norms: the extent to which certain behaviours are commonly done (Keizer & Schultz, 2013). Furthermore, the current research did not include a measure of fuel poverty, but given the prevalence of this issue in the social housing sector this could also be an important contextual factor to consider when examining energy saving behaviours. Also, financial concerns were suggested as a factor potentially underlying the relationship between CDM problems and energy saving behaviour, and may well play an important role in explaining energy saving behaviours especially in the social housing context. A future study could take into account a range of different motives in addition to environmental, such as health and financial motives. Furthermore, the current study examined a potential moderation effect between contextual and psychological factors on behaviour as proposed by previous research (Guagnano et al., 1995; Steg & Vlek, 2009). But other relationships may occur, for instance Steg and Vlek (2009) also discuss situations in which contextual factors may have a

direct effect on behaviour, or where the effect of contextual factors on behaviour is mediated by psychological factors. As discussed by Stephenson et al. (2010), internal, psychological factors and the external, material culture are likely to interact in many ways, and only by examining their influence together can we start to unravel some of these relationships.

4.3. Conclusions

Reducing energy consumption in the social housing sector may be an important route towards improving the financial situation of the residents and alleviating fuel poverty. This study aimed to provide further insight into the contextual and psychological factors that relate to energy saving behaviour in this setting. In this case, dwelling characteristics were only able to offer a small contribution to our understanding on energy saving behaviours in social housing residents once psychological and socio-demographic factors were accounted for. But the results do suggest a number of interesting implications and routes for further research. Two key findings are worth emphasising. Firstly, the regression results suggest that problems with condensation, damp and mould could be more strongly related to heating-related energy saving behaviours compared to psychological variables from the theory of planned behaviour. This relationship needs further study, but highlights the important role that the need for comfort could play in driving behaviour. However, there is a potential risk here in that reductions in energy use, particularly related to heating, could cause further CDM problems. Thus, when designing energy conservation campaigns, especially for low-income households, it is important to keep in mind that although energy savings in some areas may help relieve financial pressures which could help in improving thermal comfort and reducing CDM problems, energy savings in other areas may actually exacerbate CDM problems. Secondly, the current research provides some indication that subjective norms may relate more strongly to energy saving behaviours when people live in relatively energy efficient homes. Therefore, a social norms approach to encourage energy saving may not be an effective approach when the target population lives in houses with low energy efficiency.

Above all, energy behaviours are extremely complex (Lopes et al., 2012; Stephenson et al., 2010). Further research is needed that bridges the gap between building and social science literatures and examines interactions between contextual and psychological factors, to truly advance our understanding and allow us to design effective energy saving programmes.

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