



Original research article

Thermal comfort or money saving? Exploring intentions to conserve energy among low-income households in the United States[☆]

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ABSTRACT

Low-income households comprise an important, but often-neglected, target population for energy reduction in the U.S. residential sector. Previous research of this population tends to emphasize demographic and economic factors with little consideration of social-psychological variables. This paper utilized the theory of planned behavior (TPB) to investigate how demographics, climate zones, and a set of social-psychological variables, including energy concern, bill consciousness, frugality attitude, and thermal comfort (needs for coolness and warmth) influenced energy conservation intentions among 248 low-income households across the U.S. Results indicated that the three TPB variables alone (attitudes toward energy-conservation, subjective norms, and perceived behavioral control) had positive effects on energy conservation intentions. Attitudes toward energy-conservation and perceived behavioral control remained as the strongest predictors after accounting for other variables. Meanwhile, bill consciousness positively predicted energy conservation intentions, whereas needs for warmth and coolness negatively predicted intentions. Gender and climate zones predicted intentions when other variables were not included in the model. This study provides important insights on low-income households' energy-conservation intentions, as well as the antecedents and potential barriers, which provide useful recommendations for future energy policy initiatives.

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1. Introduction

The residential sector in the U.S. is responsible for an estimated 22% of the country's primary energy consumption [1]. Even though energy-efficient technologies have been readily developed to reduce societal energy consumption, energy use in residential buildings has still increased by 24% from 1990 to 2009 [2]. Specifically, residents' energy behaviors account for nearly 30% of the variance in overall heating consumption and 50% in cooling consumption.; thus, simple behavioral changes could yield energy saving potential of 10–20% [3]. Scholars suggest that residents'

energy behaviors have a tremendous impact on energy consumption in society, and ultimately, these actions have the potential to influence the reduction of U.S. greenhouse gas (GHG) emissions [4–6].

Low-income households (LIHs) represent an important, but often-neglected, segment of the residential energy sector [7,8]. As energy demands rise, so does the burden of associated energy costs upon American households. LIHs are a suitable group to target for energy saving efforts since they comprise one of the most vulnerable groups to these rising costs [9]. LIHs spend a higher proportion of their income (26%) on utility costs compared to the average U.S. household (4%) [10]. This is due in part to not being able to afford new technologies and enjoy the energy-saving benefits of those technologies [11]. Scholars argue that a combination of the following factors contribute to the burden of energy costs in LIHs: (1) energy prices, (2) building and appliance inefficiencies, (3) socioeconomic demographics, and (4) behavioral patterns of residents [8,13–15]. Among the aforementioned factors, behavioral patterns and their impacts on residential energy use are less stud-

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ied among low-income population. Lower levels of participation in energy-conservation programs and practices among LIHs indicate that it may be a challenge to engage LIHs in energy-efficiency programs. Current energy-efficiency programs for LIHs, which are largely funded by federal sources and utility companies, typically emphasize weatherization, device upgrades, and capital improvements to homes [12]; however, these incentives typically do not cover the cost of capital upgrades in full. Many LIHs cannot afford these upfront costs for energy-efficient upgrades, even when the upgrade would save them money on energy costs over time [13]. In addition, behavioral measures and associated cost effectiveness are often difficult to isolate and quantify, so federal and utility-funded energy-efficiency programs generally do not incentivize behavioral interventions targeted toward energy-conservation [13].

Importantly, few studies have specifically investigated how social-psychological factors shape energy consumption among LIHs based on theories. For example, some European studies (e.g., [14,27]) reported that income and household size are positively related to the level of energy use. Additionally, households with higher incomes were more likely to purchase in-home insulation than lower income households. However, these studies did not specifically analyze the social-psychological variables affecting low-income population's energy use or energy-saving intentions. Podgornik et al.'s [16] evaluative study found that the employment of smart meters alongside customized and adaptive consumption feedback are effective in reducing electricity consumption among European LIHs. Yet, the social-psychological contributors to energy behaviors among LIHs are unknown. Similarly, Opower, a software-service provider to utility companies, conducted an extensive analysis of energy-efficiency programs for LIHs in the U.S., but the social-psychological variables relating to the adoption of these programs were not analyzed [12]. Langevin et al.'s [7] study explored the attitudes, behavioral tendencies, and energy knowledge gaps among LIHs, but the study failed to include more analysis on the social-psychological factors grounded in theories. Ultimately, as suggested by Sovacool [17], much of the energy research habitually excludes sociological variables from energy decisions (e.g., attitudes and human behaviors, marginalized social groups, energy-making decisions, and issues of inequality and concentration of wealth).

Investigating the motivation of conserving energy within LIHs is compelling because these households have diverse characteristics and their motivations might also be complex and non-uniform [18]. For example, Southern California Edison (SCE) once categorized their low-income customers into five unique clusters including "Declining Health/Wealth," "Divided Household," "Hostage to Domicile," "Concerned but Uninformed," and "Merry Users." The cluster of "hostage to domicile," which accounted for 24% of the total population, was comprised of people living in older homes who had no means to improve their homes—similar to many other LIHs who rent and cannot control the efficiency of their building units. In contrast, the cluster of "concerned but uninformed" (19%) consisted of younger and less-educated renters who did not understand how to save energy or had problems convincing their landlords or roommates to cooperate [19]. Given the diverse characteristics of LIHs, it is important for researchers and policy makers to better understand the factors and mechanisms influencing energy conservation among this group.

As stated above, previous studies fail to address social-psychological factors in energy research. In addition, There is also a lack of understanding toward the effect of climate zones in energy behavioral research. Specifically, residential heating and cooling demands greatly vary from one climate to another, while perceptions of residents' thermal comfort (and associated energy use) may be largely dependent upon local weather conditions and the energy-efficiency measures installed In addition[20]. For example,

several studies have demonstrated that hot summer and warmer winter climates in China have a significant impact on energy use in the built environment [20–22]. Therefore, it is important to explore the relationship between climate zones and energy-saving intentions. Additionally, there is an opportunity for interdisciplinary research to blend these aspects of energy, engineering, and social science to better understand LIHs' intentions to conserve energy.

Our research focused on a sample of LIHs in the U.S. due to the aforementioned increase in energy costs, the significant impact of U.S. residential energy use on GHG emissions, and the potential opportunity for increased energy and cost savings via behavioral interventions within LIHs. It is our expectation that the study findings can be compared with future research on LIHs' energy behaviors, needs, and barriers in other countries. This type of study and methodology could certainly be duplicated in other countries; however, we focused on one country to minimize possible confounding effects from different policies, cultures, country climate influence, and so on. This study provides an important and timely contribution by exploring the ways to improve energy savings in LIHs through the examinations of a set of social-psychological factors based on the theory of planned behavior (TPB), as well as the evidences of demographics and climate zones. Specifically, this study focused on residential energy-use behaviors related to space heating and cooling.

2. The theory of planned behavior

The TPB has been widely used to examine a variety of environmental behaviors within residential and organizational settings. Numerous empirical studies have found the TPB model useful in predicting environmental behaviors and behavioral intentions [14,15,23–25]. For example, the TPB variables have been found to be positively related to energy-saving behaviors at work [15] and intentions to perform environmental conservation behaviors at home [26,27]. Likewise, strong support was found in a cross-national study for the TPB's predictive power in explaining environmental conservation [24], intentions to adopt residential solar energy systems [25], and support of renewable energy policy [44,46]. Finally, in an intervention study on Dutch households, Abrahamse and Steg [27] found that the TPB and other psychological variables were associated with changes in energy savings, but not with energy use.

The TPB suggests that human behavior is based on a series of conscious and rational decision-making processes [32]. Individual behavior is guided by three factors: (1) attitudes toward the behavior (i.e., overall evaluation of that behavior), (2) beliefs about the normative expectations from significant others (i.e., subjective norms), and (3) beliefs about the presence of factors that may facilitate or hinder the performance of the behavior (i.e., perceived behavioral control [PBC]). According to the TPB, the major antecedent of a behavior is an individual's intention toward that behavior, which, in turn, is influenced by attitudes, subjective norms, and PBC. In a meta-analysis study, Armitage and Connor [29] found a consistently strong and positive relationship between behavioral intentions and behaviors in the TPB literature.

Following previous research (e.g., [31,34,35]), one of the primary goals of this study is to explore the role of attitudes, subjective norms, and PBC in determining LIHs' intentions of conserving energy. Importantly, this study extends the TPB model by including additional variables relating to energy conservation: energy concern, bill consciousness, frugality attitude, and thermal comfort needs. These supplemental variables were added because scholars have suggested that an extended TPB model has better explanatory power in predicting pro-environmental behaviors [15,30,31].

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