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Personality traits and energy conservation

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HIGHLIGHTS

- We explore the personality driving resident behavior change under peer pressure.
- We map the distribution of behavior clusters driven by personality and benchmarks.
- The model is tested using data from an experiment conducted in Maryland, U.S.
- The population exposed to normative feedback can be divided into six categories.
- A personality trait-based home energy reporting mechanism is proposed.

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ABSTRACT

As a cost-effective solution to energy conservation, behavior based method focuses on changing people's behavior through normative feedback for energy efficiency. While the application of behavior-based method is promising, the challenge exists to achieve efficiently sustainable behavioral change. Based on multi-period observation of energy behavior at the Joint Base Andrews in Maryland, this paper presents a model-based approach aimed to improve the nationally popular and deep-seated benchmark setting strategy for normative feedback used in home energy reports. The improved approach has its merits of countering the undesirable boomerang effect and enhancing the effectiveness of normative feedback targeting different personalities. By introducing a modified opinion dynamics model, this paper simulates the process of energy behavior change and therefore identifies the driver and elementary rules of behavioral change. In particular, the paper defines various behavioral zones in accordance with people's personality and proposes a new customized energy reporting mechanism that maps normative benchmark to personality trait. The new energy reporting policy has strong industrial implication for promoting behavior-based method towards a sustained energy conservation movement.

1. Introduction

The building sector plays a vital role in energy conservation. Almost 40% of all energy consumed in the United States was attributed to the residential and commercial buildings. And the retail sales of electricity to the residential buildings alone accounts for approximately 38% of the total market in the past five years. The share was anticipated to increase by 21% over the next 25 years due to climate change, household size growth, and automotive electronic devices (AEO, 2014). Significant efforts have been made in the development and deployment of economic incentives and new technologies, which undoubtedly led to an increase in building energy efficiency. While there is still more ground to gain in this area, one study indicated that implementation of readily available technologies can result in energy savings of nearly 30% (Gardner and Stern, 2008). Yet, for all the technological advancements in building energy conservation, technology alone cannot obtain the full potential of energy savings (Jain et al., 2013). The residents themselves must decide to adopt the new technology, employ it correctly and, perhaps most significantly, adjust their lifestyles, attitudes, and behaviors.

Influencing behavioral change in energy use, also termed as behavior-based energy efficiency in the energy industry and major initiatives of U.S. Department of Energy, is cost efficient and has a great potential to achieve building energy conservation. The method is typically implemented through education, outreach activities, or normative feedback. After studying 36 residential energy efficiency programs launched by The American Council for an Energy-Efficient Economy (ACEEE), Ehrhardt-Martinez et al. (2010) found that 4–12% annual electricity savings were reached through normative feedback, i.e. providing residents with their

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energy use and making normative comparison to their peers. Another similar behavior change experiment initiated by Cool Choices showed that its normative feedback program generated a median energy savings of 6–9% (Bensch, 2013). The application of this behavior-based method can create significant economical benefit. The practice of Opower (2013) demonstrated that changed behavior could lead to approximately $2.2 billion per year in electricity bill savings for the U.S. households.

However, the normative feedback method has been criticized for its short-term influence on behavioral change. Currently, normative feedbacks are applied universally to all households with the energy use information on the community average or top 20% energy efficient households. While this method attained a positive influence on the over-consuming households, a great number of residents who consumed less could potentially relax their energy conservation habits and be tempted to increase their energy use after learning average consumption level in order to conform to the social norm. This sort of undesired upshot is known as "boomerang effect". Being observed in many normative feedback experiments (e.g., Schultz et al., 2007; Fischer, 2008; Ayres et al., 2012; Sælen and Westskog, 2013), these negative effects remain a serious challenge in energy conservation programs for successful scale-up. Furthermore, the drivers behind successful behavior-based energy conservation programs remain poorly understood. Moreover, the ability for normative feedback to facilitate the interaction between households (especially neighbors) about their utility bills and behavior imitation of each other is almost entirely unexplored (Vine et al., 2013). Neither is known why the same behavior based approach leads to different energy savings results in different communities. This research starts with the questions: what feature of a community or people contributes to the behavioral changes? Can we improve the energy savings results by providing multiple normative benchmarks?

With the objective to understand the dynamics of normative feedback, this paper presents an opinion dynamics model for energy conservation. The model is designed to examine the impact of personality traits on behavioral change and furthermore analyze information transmission mode under various normative feedback patterns and benchmarks. This paper is structured as follows: Section 2 reviews theories of personality traits and social norms with respect to their application to energy conservation behaviors, and a modified opinion dynamics model is developed and analyzed. Then, the details of experiment, data information of data collection and model validation are presented in Section 3. Section 4 proposes a new normative feedback mechanism that customizes home energy reports according to individual personality. The last section summarizes the findings and policy implications.

2. Research methods

2.1. Personality traits and energy conservation behavior change

Before entering this section, we shall first clarify the concepts of energy efficiency and energy conservation. These two terms have been often used interchangeably in the industry practice and even in government programs. Some studies claimed that they had different meanings in behavior based energy research. For instance, Oikonomou et al. (2009) specially highlighted that energy saving and energy efficiency should be treated differently from the microeconomic perspective in the context of energy behaviors. They argued that the former was focused on a change in consumers' behavior, while the latter addressed the technical ratio between the primary or final energy consumption and the maximum quantity of energy services obtainable, which typically referred to adopting a more efficient technology to reduce energy use. Consisting with them, Barr et al. (2005) labeled energy related behaviors as purchasing activities (energy efficiency choices) and habitual actions (energy-saving activities). Accordingly, we use the term "energy conservation" in this paper since we are concentrated on the analysis of energy-related behavioral change.

Targeting energy conservation in residential sector, a multitude of studies have tested the effectiveness of a series of behavior intervention strategies. For instance, the monetary reward-intervention (Mizobuchi and Takeuchi, 2013; du Can et al., 2014) leads to desired energy savings at the first month but cannot persist the conservation across time (Abrahamse et al., 2005), while the efficiency is strengthened if combined with normative feedback (Mizobuchi and Takeuchi, 2013). Carrico and Riemer (2011) showed that group-level comparative feedback yielded higher energy savings of 8%, while peer education generated a lower 4% reduction. Indeed, information-only campaigns ([Henryson et al., 2000,Lindén et al., 2006]) need a long term to change residents' behaviors, and the influence is very limited on energy conservation (Steg and Vlek, 2009). Thus, drawn on these existing theoretical and empirical evidences, they all have limited effect, which makes a more cost-effective alternative – normative feedback approach catches the general attention (Kurz et al., 2005; Allcott and Mullainathan, 2010; Peschiera and Taylor, 2012; Schultz et al., in press). This phenomenon has it foundation in the social norms theory. The theory states that people have a disposition to adjust both their attitudes and behaviors towards what they comprehend as normal attitudes and behaviors. Based on this property, social norms have the advantage of eliciting favorable behavior change especially in the community where the residents do not hold financially accountable for their energy use (Anderson et al., 2013). In the context of household energy conservation, by offering residents their energy usage and making normative comparison with peers, up to 12% of energy reduction can be achieved. This approach is referred to as normative feedback. In addition, this approach has better performance in residential buildings than in commercial ones since a resident can directly change the energy related behavior once he/she found the utility energy bill increased (Azar and Menassa, 2013).

The normative feedback method follows a "one-size-fits-all" process. Typically, residents receive normative feedback via a home energy report. In the report, there are three bars on the chart, one is the monthly electricity consumption of the subject household, second is the average for all community, and the third is the average for the most efficient 20% of the neighbors in the community (Allcott, 2011; Burchell et al., 2013). This report only reveals to receiver the average value and the most efficient 20% value as two normative benchmarks for comparison. As more normative feedback studies report results, many have demonstrated that this type of reporting leads to the desired effect. For example, Nolan et al. (2008) showed the normative feedback group identified a 10% decrease in energy consumption, which was compared to a control group that was only provided with energy saving tips. But some studies found undesirable boomerang effects (e.g., Fischer, 2008; Ayres et al., 2012). After this discovery, research works have mainly focused on ways to eliminate this unintended rebound phenomenon. Schultz et al. (2007) demonstrated that adding an injunctive message can counter the boomerang effect in household energy conservation context. While Ayres et al. (2012) illustrated that this type of message may not eliminate the boomerang effect among its experiment with 35,000 participants who were provided normative feedback. More interestingly, a study examined the efficacy of normative feedback with descriptive norm only and multi-component normative feedback which invoked an injunctive norm in the college student drinking context, but neither of them was observed a boomerang effect among lighter drinkers (Prince et al., 2014). Other studies in