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Behaving or not? Explaining energy conservation via identity, values, and awareness in U.S. suburban homes

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ABSTRACT

In this study, we compare electricity consumption of the suburban households with similar socio-economic, demographic, and geographic profiles to assess possible roles of social-psychological and behavioral factors. We examine the extent to which these factors influence self-reported energy curtailment (EC) and energy efficiency (EE) behaviors. We also analyze their distinct yet combined roles—often lumped together in the literature—in explaining the total household's electricity consumption. Our study uses a mix of survey responses and monthly utility data from 155 households in a suburban county in the US Midwest. Our two-part empirical analysis using structural equation modeling and multi-linear regression methods suggests a significant role of pro-environmental identity, values, and awareness in explaining households' energy conservation behaviors, while controlling for socio-economic and demographic profiles. Our analysis also suggests a unique role of annual income in mediating conservation behaviors– negatively related to EC behaviors but positively related to EE behaviors. We believe that this is the first study in the US context to empirically test the direction, extent, and combined role of the reported EC and EE behaviors using actual electricity consumption data. With better insight on the role of factors underlying the reported EC and EE behaviors, this study not only adds to the current literature on residential energy conservation but also provides empirical support for the design of targeted and effective energy conservation policies.

1. Introduction

Despite energy saving potential, technological progress, and continued research attention, the residential energy consumption literature remains theoretically fragmented, inconclusive, and subject to continued debate. Traditionally, residential energy conservation measures have largely focused on technical innovations, financial incentives, and improvements in economic efficiencies with theoretical explanations drawn from physical, technical, and economic analytical traditions [1–3]. Lately, scholars have highlighted the need for understanding and including lifestyle, social, and behavioral factors of household occupants in analyzing residential energy consumption [2,4,5]. Contemporary literature classifies energy conservation actions under two broad domains of energy curtailment (EC) and energy efficiency (EE) behaviors, notwithstanding alternate classifications that include maintenance and sufficiency behaviors [6–9]. Broadly, EC behaviors are routine, repetitive actions to decrease consumption on a day-to-day basis that require cutting down on comforts or result in lesser economic utility to achieve

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energy savings [10,11]. Common examples include adjusting thermostat settings, switching off lights, limiting use of heating systems, unplugging appliances when not in use, etc. [6,7]. In contrast, EE behaviors are primarily related to one-time investments[1] such as purchasing new energy efficient appliances or upgrading the building insulation without curtailing economic utility or the level of energy services [12–17]. With a few recent exceptions [2,18,19], these two types of behaviors have been studied separately from the social psychology and economics literature. Generally, EC behaviors are theorized to be driven more by social-psychological factors and environmental concerns in comparison to the EE behaviors, which are largely explained by financial considerations and behavioral anomalies [7,20,21]. While a few studies have explored the dichotomy between these behaviors to analyze their combined role in residential energy conservation [2,14,19], to the best of our knowledge, there is no peer-reviewed study that empirically tests the combined role and extent of the predictors of EC and EE behaviors on the actual electricity consumed in US households.

In this study, we analyze the role and extent of potential factors underlying EC and EE behaviors while controlling for the physical, socio-economic, and demographic profiles of residential households. Based on our literature review of the *what* (factors are associated with household energy consumption) and *why* (different types of households are likely to behave differently) questions in residential households [7], we explore the *how* (concerning the direction and interactions) and *how much* (significance and extent of their contributions) questions in explaining the aggregated electricity consumption of the households by using a mix of research methods, data sources, and analytical approaches. We draw empirical findings by merging household survey responses with longitudinal electricity consumption data from 155 residential households in a suburban county in the Midwest US. To analyze predictors of reported EE and EC behaviors and their combined role in explaining the total electricity consumption, we explore the following research questions:

(i) Do social-psychological variables including pro-environmental identity, values, and moral obligation affect reported EC behaviors?
(ii) How do personal attributes such as *status quo* bias, lack of billing awareness, and appliance knowledge influence reported EE behaviors of residential households?
(iii) Is there a significant overlap among predictors of reported EC and EE behaviors?
(iv) To what extent do these social-psychological variables and behavioral anomalies like status-quo bias (hereinafter referred together as behavioral predictors) responsible for EC and EE behaviors explain the variation in monthly electricity consumption across households while controlling for their physical, socio-economic, and demographic profiles?

The remainder of this paper is organized as follows: following a brief overview of the contemporary literature on the theoretical background, analytical perspectives, and possible predictors of the residential energy conservation behaviors in Section 2, we describe our analytical approach and research design in Section 3. In Section 4, we present the results of our study, and we discuss their significance in Section 5. Section 6 concludes with policy implications and suggestions for future studies.

[1] For this study, we overlooked the distinction between purchase of portable, low-investment energy efficient appliances and high investment house insulation upgrade or retrofit actions in the long run, and lumped them together as EE behaviors despite possible differences.

2. Overview of residential energy conservation behavior

Residential energy consumption is a complex subject that depends on numerous intrinsic, extrinsic, and contextual factors that include physical characteristics of built structures, energy appliances, occupants' beliefs, values, attitudes, and various other social and economic variables [7,22]. Complexity in residential energy consumption literature is compounded further due to multiple theoretical perspectives, inconsistent nomenclature of energy related actions, and largely unknown aspects of energy use behavior despite the growing research and progress made in this field. Contemporary literature identifies four main theoretical approaches to studying residential energy use depending on the underlying explanations and analytical scales: (i) conventional and behavioral economics, (ii) technology adoption theory and attitude-based decision-making, (iii) social and environmental psychology, and (iv) sociology [12,15,23]. With dominance of techno-economic considerations in explaining the residential energy conservation actions in the past, scholars have highlighted the need for understanding them from lifestyle, social, and behavioral perspectives using insights from social sciences and humanities disciplines [1]. However, the literature on residential energy consumption remains fragmented and subject to lively debate even within social science disciplines. Whereas the study of residential energy consumption drawing from the techno-economic and psychological literature focuses on the individual attitude, behavior, and choice/context/external conditions (ABC), the sociological literature relies more on the energy consumption practices that are shaped by the social, cultural, and economic factors in a dynamic setting [24–26]. Some scholars have contested the individual energy consumption behavior change arguments based on ABC models. Instead, they highlight the role of energy consumption practices as an umbrella concept that draws from science and technology studies (STS) theory and Foucauldian concepts of governmentality, among others [27,28]. In the absence of an overarching model that can comprehensively explain the dynamics of residential energy consumption behavior, scholars have noted the relative strengths and limitations of the individual approaches and highlighted the need for integrating different perspectives. For a comprehensive review of the different theoretical perspectives and associated debates on residential energy consumption, see [7,15,23,29,30].

2.1. Multiple perspectives on residential energy conservation

In general, energy conservation activities relevant for environmental benefits have been considered part of pro-environmental behaviors and studied as ‘energy efficiency,’ ‘green behaviors,’ and ‘sustainable behaviors,’ notwithstanding the underlying similarities and subtle differences between them [31,32]. A broad and inclusive definition of energy efficiency encompasses the notions of conserving energy while sustaining everyday life and well-being [21,33]. In this sense, energy conservation behaviors have been treated as a unidimensional construct by Kaiser [34], in contrast with the opposite view held by Stern [35], who maintains that such behaviors should be studied individually [13]. A third midway approach identifies and classifies energy conservation behaviors into a few distinct categories. As an example, energy consumer actions have been distinguished as energy efficiency, curtailment, and maintenance behaviors depending on the focus on acquisition, use, and disposal of energy services [7,8]. Another study classifies pro-environmental behaviors into two broad categories as reasoned and unplanned behaviors, noting that the actual behaviors are far more complex, interrelated, and are not neatly categorized [36]. Using a broader theme of absolute limits on a range of resources, scholars have also distinguished between the concepts of efficiency and sufficiency in the context of energy consumption and carbon emissions [9,37–39].

2.2. Energy efficiency versus curtailment behaviors

Karlin et al. [6] identify two main dimensions of energy conservation actions as energy curtailment (EC) and energy efficiency (EE) behaviors, distinguished primarily based on their cost and frequency attributes. In general, EE behaviors are identified more with one-time, cost incurring investments in efficient appliances and retrofits, while EC behaviors include repetitive, low-cost energy saving efforts [6,40,41]. Drawing on literature from across the social sciences, Frederiks et al. [30] conducted a review of the individual level predictors of household EE and EC behaviors. Noting the absence of any single conceptual framework that is universally accepted, they found a multitude of socio-demographic (e.g., income, education, household size, dwelling type, stage of family life cycle), psychological (e.g., knowledge, values, attitudes, motivations, intentions, social norms), and external (e.g., socio-cultural, economic, political, legal, institutional forces) factor explain energy conservation behaviors [30].

Taking a holistic view of residential EE and EC behaviors, Vasseur et al. [7] identify and classify predictors as internal (socio-demographic, contextual factors, attitudes, behaviors, and habits), external (incentives, institutional, and infrastructures), and social contextual (social norms, identity, and practices/systems).The authors also note the trade-offs associated with capturing the complexities of these behaviors across different theoretical models [7]. From the review, it appears that the most common theories tested in explaining EC behaviors are: theory of planned behavior (TPB) [42], value-belief-norm (VBN) theory [43], values-environmental self-identity-personal norms (VIP) theory [44,45], norm activation theory [46], model of pro-environmental behavior [47], and attitude-behavior-external conditions model [26] among many others.

Despite this conceptual plurality, social scientists generally agree that there is a difference between what people say or think and what they actually do. This discrepancy between professed values, knowledge, attitudes, and actual pro-environmental actions has been variously described in the literature as value-action gap [29,48], knowledge-action gap [49,50], and attitude-behavior gap [47,51,52]. In the context of household consumption, it is often observed that energy consumers do not utilize efficient products and techniques to their full potential in their daily lives despite apparent benefits. This disconnect between theoretically available cost-effective EE potential and actual realized savings has been described as the “energy efficiency gap” [53] or “energy efficiency paradox” [54]. In this sense, energy efficiency behavior can be seen as the converse of ‘energy efficiency gap’ embedded in the reluctance of individuals to invest in efficient technologies with energy inefficient actions explained in terms of factors responsible for the ‘energy efficiency gap’.

Researchers have differed on theoretical explanations for the EE gap and the effectiveness of energy efficiency measures to bridge that gap [55]. Jaffe and Stavins [53] suggest that the EE gap is due to the existence of market barriers such as lack of awareness about efficient products and services (information asymmetry), segregation of energy use and equipment costs between landlords and tenants (principal agent issues), and lack of enabling institutional and financial resources causing liquidity constraints (capacity constraints). Others have contested the assumptions of rational behavior in explaining the EE gap based on insights from *Prospect theory* [56]. They suggest behavioral anomalies such as decision heuristics, limited attention, present-bias, and inertia help explain EE behaviors [54,57]. Separately, Brown and Sovacool [29] tabulated at least fifty theoretical approaches for the EE value-action gap and classified them under two broad categories depending on whether they emphasized (i) beliefs, values, and attitudes from the perspective of individual decision-makers or (ii) contextual factors and social norms [29]. From a policy perspective, it is important to understand the role of factors underlying EC and EE behaviors and analyze their overall contribution in limiting total energy consumption and carbon emissions. In the residential households' context, comprehensive policy design will not only require information about behavioral choices in purchase of energy appliances or use of energy services but also involve empirical analysis of how these factors interact with other socio-economic and demographic profiles in a real-life setting. As an example, it is important to understand the nature and extent of the relationship between household income and EC and EE behaviors to ensure benefits and burden of residential energy policies are distributed equitably and do not perpetuate the energy burden further.

2.3. Empirical findings on the EC and EE behaviors

In comparison to studies on conceptual understanding of EC and EE behaviors, empirical literature on the role and extent of their underlying predictors is limited and few studies analyze both behaviors. Drawing from the VBN and VIP theories, a recent study compared self-reported food, energy, and water (FEW) conservation behaviors based on a national survey data for the US households. It not only found a significant relationship between biospheric values, environmental self-identity, and personal norms but also noted that personal norms contributed significantly to the reported intention to conserve FEW resources [11]. Another study on Greek households analyzed relationships between self-reported energy (electricity) curtailment behaviors and their demographic/structural, psychological, and moral predictors. Using electricity curtailment behavior as the dependent variable, the study found a significant influence of demographic (age, gender) and psychological variables (perceived behavioral control, attitude, and subjective norm). However, moral variables (feelings of regret, moral norms) were not significant [13]. A study compared the role of pro-environmental self-identity, biospheric/altruistic values [58], and perceptions of climate knowledge on water and electricity curtailment behaviors in China and Poland, finding identity predicted curtailment behaviors in both countries. However, the exact nature and extent of their influence were found to be differently mediated by values, lack of knowledge, and other contextual variables in the two countries [59].

A recent study explained EE behaviors of residential households based on a choice experiment using variables from prospect theory, finding that loss-averse people are less likely to invest in energy efficiency appliances [60]. Others found that total electricity consumption was higher by 5.7 % when the respondents were status quo biased [61]. In a comparative study of US and Canadian households, environmental concern, values, and lifestyle orientation were found to influence green purchasing behaviors in combination with socio-economic factors [4]. Another study on passenger car market sales using Monte Carlo simulation suggests that a combination of behavioral factors, namely, loss aversion and uncertainty of future savings can explain the bias against energy efficiency [62]. To understand EE behavior, a study on UK households used a combination of ‘Q methodology’[2] and survey questions using an ‘energy culture framework’ [25,63]. It found environmental responsibility and saving money as strong themes affecting energy efficiency behaviors. However, mere possession of environmental knowledge and motivation did not automatically lead to energy-efficient behaviors [64].

This review demonstrates how the concept of energy conservation behavior has been used and described differently across studies with no uniform and standard measurement method. Most empirical studies assess residential energy conservation behavior either in terms of metered energy consumption values or construct it from survey responses to different EC and EE actions. One of the most commonly cited empirical studies on residential energy conservation behaviors in the U.S. uses home energy reports comparing monthly electricity consumption

[2] ‘Q methodology’ uses a set of cards with pre-identified questions to identify subjective viewpoints. It is considered an efficient method in exploring subjective topics that involve complex viewpoints in comparison to the study of individual behaviors using survey questions.

of households with the average consumption of the neighborhood and nudges consumers to save electricity [65].

Few studies have also tried to explore the dichotomy between energy curtailment and energy efficiency behaviors. Drawing from the self-reported behavior of respondents from 22 countries in the European Union, Umit et al. [19] studied the role of household income on energy efficiency and curtailment behaviors. They found that while income correlated positively with the likelihood of buying energy efficient appliances, it had a negative effect on engaging in curtailment behaviors [19]. Another empirical study of Irish consumers investigated the trade-off between curtailment and efficiency behaviors. Using time-of-use pricing and feedback information through smart meters, it found that while the overall and peak electricity usage reduced, the intervention had an unintended effect of reducing the energy-efficient investment for the household [14].

Recently, McAndrew et al. [21] conducted a systematic review of household energy efficiency intervention literature using an inclusive definition of energy efficiency that includes different energy conservation behaviors. Out of a total of 153 interventions reviewed by the authors, less than half mentioned theoretical models with the most common approaches drawing from social norm theories, followed by theories of planned behavior, behavioral economics, and social practice, respectively. Eighty-five interventions did not mention any specific theory, model, or conceptual framework, and very few interventions used multi-theoretical or inter-disciplinary approaches despite recommendations in recent literature [7,12,15].

Ideally, measuring energy efficiency behavior should capture the 'energy efficiency gap' embedded in the reluctance of individuals to invest in efficient technologies that are considered cost-effective in the long run. Alternately, it should reflect the distinction between the hypothetical efficient energy consumption level and the actual business as usual or baseline energy level of households [53]. However, there appears to be no empirical study to the best of our knowledge that tests the role and extent of underlying behavioral factors to explain the EE gap (or conversely EE behavior) using the difference between actual and hypothetical levels of energy consumption as the outcome variable. Moreover, there is no consensus on the exact levels of the baseline and techno-economic efficient levels in the EE program evaluation literature to account for free-ridership, spillovers, prebound, and rebound effects with potential consequences on net energy savings [66–68].

2.4. Research hypotheses

Given the complex nature of energy conservation behaviors embedded in the socio-economic context of residential households, choosing any one analytical approach involves tradeoffs between simplicity and accuracy. For our analysis, we analytically distinguish between the causes, explanations, and background theories of EC and EE behaviors despite possible overlaps and absence of clear boundaries between them. Instead of restricting our study to test any one theory or model, we relied on a mix of underlying variables for reported EC behaviors from the value-belief-norm theory [43], the values-environmental self-identity-personal norms theory [44,45], and the norm activation model [70–72] from the environmental psychology literature. Based on our review and data availability, we studied the role of pro-environmental identity [22,59]; values or life goals [73]; and personal norms evident in the moral obligation to act environment friendly [7,74] on EC behaviors.

For EE behaviors, we relied on behavioral anomaly variables from the behavioral economics literature that explain investment decisions in efficient appliances based on heuristics and non-standard preferences. We included variables caused by status quo bias [57,61], lack of knowledge or awareness [6,74–76], and principal-agent issues in home ownership [54] to test our hypotheses. We also controlled for the role of socio-economic and demographic factors such as affluence measured as household income [2,7,77], average age of household members [7,73], presence of kids [78], and political views [19] in affecting energy consumption through reported EC and EE behaviors. Based on our literature review and data availability, we tested the following hypotheses from our conceptual model (Fig. 1).

Hypothesis-1(H1): Pro-environmental identity, values, moral obligation, and annual income affect reported EC behaviors.
Hypothesis-2(H2): Billing awareness, appliance knowledge, annual income, and status-quo bias affect reported EE behaviors.
Hypothesis-3(H3): Reported EC and EE behaviors are significantly related to each other.
Hypothesis-4(H4): Social psychological variables underlying the reported EC behaviors (pro-environmental identity, values, and moral obligation) indirectly affect the monthly electricity consumption compared to the neighborhood average.
Hypothesis-5(H5): Behavioral anomalies underlying the reported EE behaviors (billing awareness, appliance knowledge, homeownership, and status-quo bias) indirectly affect the monthly electricity consumption compared to the neighborhood average.

3. Analytical approach

3.1. Model description

Our deductive analysis is in two parts. First, we assess the potential role, significance, and interactions among the behavioral predictors in explaining reported EC and EE behaviors (Hypotheses H1 and H2) using structural equation modeling (SEM). Due to its ability to represent complicated relationships between the observed and latent variables with the help of path diagrams, SEM is becoming increasingly popular in the social and behavioral sciences [79]. SEM differs from the usual single equation regression models that have a single dependent variable and multiple covariates. Structural equation modeling also allows estimating multiple relationships between exogenous and endogenous variables with measurement errors [80]. Using survey responses, we construct the reported EE and EC behaviors as latent variables using the path coefficients from the SEM analysis. We also test Hypothesis H3 on the possibility of significant overlap between the EC and EE behaviors using SEM analysis. Next, we test Hypotheses H4 and H5 on the direction and extent of these behavioral predictors in explaining monthly electricity consumption and their variation across residential households, while controlling for physical and socio-economic variables using a mix of models based on the linear regression methods. The mathematical formulation for multivariate regression method used is as follows:

$$Y_{it} = \alpha_i + \lambda_t + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots \beta_k Z_{ki} + \beta_D \Delta_t + \varepsilon_{it};$$

where α_i are the unobserved fixed effects for the household i, λ_t is dummy variable for month t, X_i represents the behavioral variables of the households, and β_is are the estimated regression coefficients. To

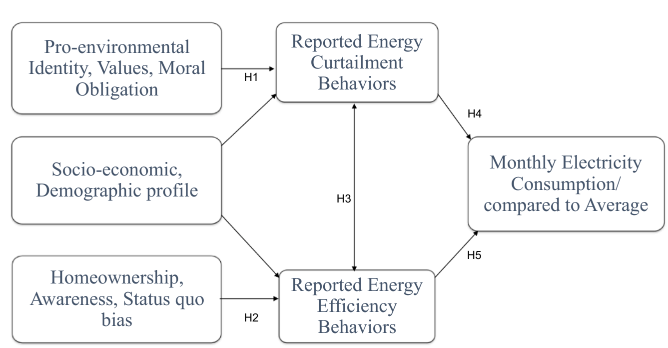

Fig. 1. Schematic diagram of the conceptual model and hypotheses tested.

approximately control for the combined effects of all factors triggered by the COVID-19 shutdown, we introduced another dummy variable $\Delta_t = 0$; if $t < 31$st March 2020 (before lockdown), and $\Delta_t = 1$; if $t > 31$st March 2020 (after lockdown). Socio-economic and demographic profile (annual household income, building vintage, average age, number of members, floor area) were retained as control variables (Z_{ki}). We estimated the variation in behavioral factors underlying EC and EE behaviors along with socio-economic factors across participating households but assumed that they did not vary significantly over time during the study period. We also ignored the role of change in electricity retail prices on the residential energy conservation behavior as its variation was insignificant during the study period.[3]

3.2. Research data

This study is part of a larger project designed to investigate methods for reducing food, energy, and water (FEW) consumption of residential households and associated direct and indirect environmental impacts, including GHG emissions, using an interdisciplinary approach. In this paper, we limited our attention to the electricity consumption behavior of residential households. We only considered residential households as the unit of analysis, overlooking possible differences in household behavior dynamics among family members [81,82]. For this analysis, we identified 155 households from our target population in a suburban Midwestern U.S. county that included a member who responded to our survey and for which we had continuous monthly electricity consumption data through a separate energy meter. We note that our sample represents one specific suburban population with relatively higher income than the national average, as such, the results from this study will have to be tested further for generalization on a larger scale.

A schematic representation of the key survey timelines and nature of survey questions asked during the year-long period is shown in Fig. 2 above (data used in this study are from enrollment, phases 1 and 3 of the surveys marked in asterisks). Due to the stay-at-home order in March 2020 following declaration of the COVID-19 pandemic, survey participation may have been affected, forming an important limitation of our study. Periodic responses to the surveys were combined with monthly electricity billing data from March to October (24 months) made available by the electricity utility 'ComEd' for the participating households during three consecutive years since 2018.

3.3. Measurement

3.3.1. Dependent variable

To study reported EC and EE behaviors across households, we chose two sets of dependent variables: (i) the actual monthly consumption values for the models 1, 3, and 5, and (ii) the difference between monthly electricity consumption for respondent $\boldsymbol{i}$ for the month $\boldsymbol{t}$ and the average consumption for all other households included in this study for the same month (as a rough measure of the baseline) in the models 2 and 4. We assume that this difference should take care of variations in energy consumption caused by weather effects as the changes should be common to all households in the county. Further, the difference between actual electricity consumption of a household and average electricity consumption for other study participants residing in the same county, after controlling for the socio-economic and housing envelope parameters, should better reflect the contribution of behavioral factors underlying the EE behavior in the absence of any uniformly accepted baseline for comparison [66,67,83–85].

3.3.2. Latent variables

Following the classification of the energy conservation behaviors into two broad dimensions, we assessed the latent constructs of EC and EE behaviors using a battery of survey questions.

Reported energy curtailment behavior (*ECbehavior*)-derived from responses to the following questions adapted from [6,13] measured on a seven-point Likert scale, coded from never = 1 to always = 7 (Cronbach's alpha value as an estimate of the internal consistency of survey questions [86] = 0.62): How often do you program the thermostat in your home? How often do you set the heat to lower temperature in winter in your home? How often do you set the AC to higher temperature in summer in your home? How often do you dry clothes on a clothesline? How often you turn off lights when you leave the room in your home? How often you wash clothes in cold water in your home?

Reported energy efficiency behaviors (*EEbehavior*)-derived from responses to the following questions adapted from [2,61] measured on a no = 1 and yes = 2 scale, (Cronbach's alpha = 0.72); whether own energy efficient light bulbs, own Energy Star rated freezer, dishwasher, or clothes washer.

3.3.3. Independent variables

For the empirical analysis, we derived the behavioral predictors underlying EC and EE behaviors from a battery of survey questions identified and adapted from previous literature and used them as independent variables. Table 1 below lists the variable names, attributes, survey questions, measurement scale, and Cronbach's alpha values as a measure of internal consistency of the survey questions. Due to low Cronbach's alpha value for the Status-quo bias variable and insufficient responses for other available survey questions related to the pro-environmental values, we used them as single question variable relying on similar arguments in the past [13,73]. It should be noted that due to the negatively worded survey question for measuring values variable, higher score on a scale of 1 to 3 implies lower pro-environmental values. We also add a note of caution that the single survey question used in our study might not adequately capture the status-quo bias variable as it measures the tendency to hold on to old appliances even after purchasing new ones rather than avoiding new purchase altogether.

3.3.4. Socio-economic and demographic variables

Based on literature review [13,19,78,91], we controlled for the effects of the socio-economic and demographic variables derived from available responses to survey questions: *annual household income* measured on an ordinal scale of 1 ($20,000-34,999) to 9 (greater than $200,000); *political views* measured on a five-point ordinal scale, coded very conservative (1) to very liberal (5); *home area* estimated in square feet on a continuous scale; *building vintage* measured on an ordinal scale of 1 (before 1950) to 8 (2010–2019); *average age* of the members in the household; *Kids* as a binary variable for presence of kids, and the *number* of residents in the households.

4. Results

We estimated the path coefficients and significance of the EE and EC behavioral predictors using Stata/MP 16.1 for Mac (64-bit Intel) SEM software based on maximum likelihood method for our hypothesized models. Stata software displays the structural and measurement equations in SEM using a box and arrow pattern with observed and latent variables enclosed in rectangular and oval boxes respectively. Measurement errors or residuals in the observed/latent variables are represented in circles with outgoing arrows. Endogenous variables have at least one-way arrow pointing toward them as against the exogenous variables that only have outgoing paths. Estimated paths coefficients with straight arrows show the strength of direct relationships between

[3] The average retail price of electricity in the US did not vary significantly during the three years of the study period from 2018 to 2020. https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=g000g&endsec=o&linechart=ELEC.PRICE.US-ALL.A&columnchart=ELEC.PRICE.US-ALL.A&map=ELEC.PRICE.US-ALL.A&freq=A&start=2014&end=2020&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=.

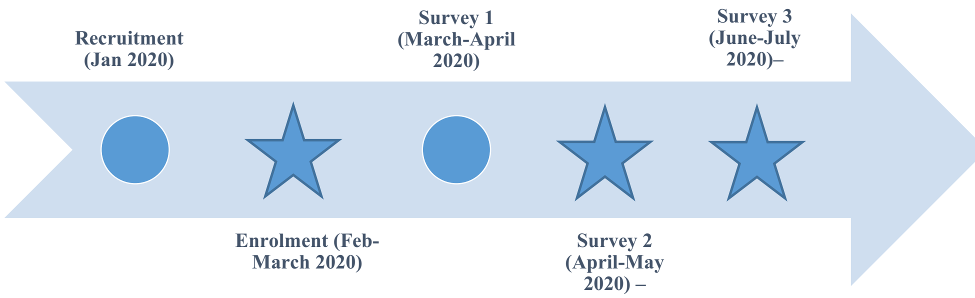

Fig. 2. Survey timeline for residential households, Midwest, US.

Table 1
Survey questions and scales for Independent variables.

Independent variable	Name	Survey questions	Scale	Cronbach's alpha	Adapted from
Pro-environmental Identity	Identity	Acting environmentally friendly is an important part of who I am I am the type of person who acts environmentally friendly I see myself as the kind of person who acts in a way that benefits the environment.	Six-point ordinal scale, coded from disagree = 1 to strongly agree = 6	0.96	[11,22,59,87]
Moral obligation	Obligation	I feel morally obliged to conserve energy, I would feel guilty if I did not take actions to conserve energy, I would feel proud to conserve energy	Seven-point scale, coded from Strongly disagree = 1 to strongly agree = 7	0.88	[11,73]
Reported billing awareness	Bill_knowledge	Do you check your utility bills online? Do you find your utility bills easy to understand? Can you assess your monthly utility bill from your energy meter? How easily you can explain different parts of your monthly utility bill to others?	Binary scale: Yes = 2, No = 1	0.54	[6,78]
Reported appliance knowledge	App_knowledge	How knowledgeable are you about the energy efficient appliances? How knowledgeable are you about the water efficient appliances? How knowledgeable are you about the energy star appliances?	Seven-point scale, coded from strongly disagree = 1 to strongly agree = 7	0.84	[73,74,87,88]
Status-quo bias	Status_quo_bias	Do you keep old stuff around even after purchasing new appliances?	Five-point scale, coded from strongly disagree = 1 to strongly agree = 5	0.57	[61,89]
Pro-environmental values	Values	How important each of the following is to you as a guiding life principle-preserving social power, dominance, and control over others.	Three-point scale coded from opposed to my principles = 1, not important = 2 to extremely important = 3	–	[11,90]
Homeownership	RE_txt_home	Whether own or rent the house	Binary scale coded 1for self-owned and 2 in case of rented house	–	[88]

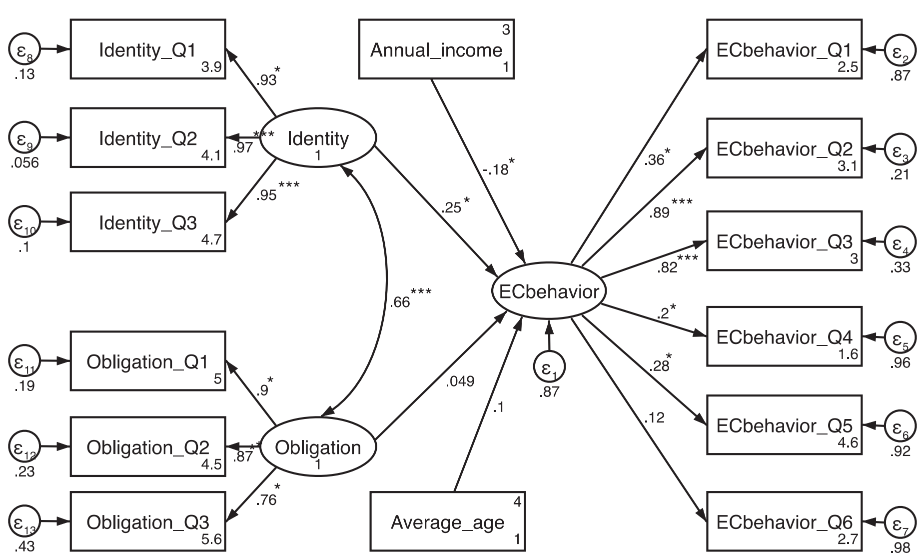

Fig. 3. Stata output showing Path diagram and results of SEM analysis for the EC behavior.

variables. Further, two-way curved arrows depict the measure of estimated covariance between variables. Model parameters are estimated using an iterative process that maximizes the difference in likelihood functions between the saturated and baseline (intercept only) models and assessed for their overall fitness [92,93].

4.1. EE and EC behaviors using structural equation modeling

We constructed *ECbehavior* as a latent variable using survey responses on the household's actions that cut down on energy services. Thereafter, to analyze the role of factors underlying self-reported EC behavior, we hypothesized pro-environmental identity and moral obligation as possible explanatory variables, while controlling for the annual income and average age of the respondents. We also tested for possible correlation between the pro-environmental identity and moral obligation variables. Fig. 3 below is the Stata output depicting path diagrams and covariances between the variables used in the model for the reported EC behaviors.

The overall model fitness indices used in assessing the conceptual models include the model versus saturated likelihood ratio chi-squared test, the comparative fit index (CFI), Tucker-Lewis index (TLI), and coefficient of determination (CD) with values 0.95 or higher considered good fit [92]. However, the likelihood ratio chi squared results are limited by changes in sample size and are not considered as the final word [92,94]. Further, the root-mean square error of approximation (RMSEA) and the standardized root mean square of residuals (SRMR) values below 0.08 are indicative of good model fit [2,94]. Estimation results and the model fitness indices are reproduced in the Table A1 attached in Appendix. The RMSEA, CFI, TLI, CD, and SRMR metrices together indicated good model fit with acceptable model versus saturated Likelihood ratio chi square test value 93.27 and p value 0.05. The estimated path coefficients suggest that the reported EC behaviors are positively and significantly related with the pro-environmental identity variable but negatively influenced by the annual household income. Further, the effect of moral obligation was not found to be significant on reported EC behavior, however, the covariance between the identity and obligation variables was significant with a value of 0.66.

Similarly, for testing the role of the explanatory variables in predicting reported EE behavior, we constructed the latent variable *EEbehavior* using survey responses on energy efficient appliance ownership. We constructed the analytical model by choosing billing awareness and appliance knowledge, home ownership status, and status-quo bias as possible explanatory variables, while controlling for respondents' annual income. Fig. 4 below depicts the path diagrams and covariances between EE model variables.

SEM estimation results and model fitness indices for reported EE behavior are reproduced in Appendix Table A2. The estimated path coefficients suggest that the reported EE behaviors are positively and significantly predicted by appliance knowledge. Annual income of respondents was found to be marginally significant (p value < 0.2) for the reported EE behavior. However, the status quo bias and billing knowledge were not found significant in affecting the reported EE behavior. We also observed significant covariance between the appliance and reported billing knowledge variables. The model versus saturated Likelihood ratio chi square test value, RMSEA, CFI, TLI, CD, and SRMR metrices together were found to indicate good to moderate levels of model fitness.

We also tested for possible overlap between the reported EC and EE behaviors (H3) using SEM analysis (path diagram shown as Fig. A7 in Appendix. However, the covariance (−0.072) was not found to be statistically significant.

4.2. Residential electricity consumption using confirmatory factor analysis and multivariate linear regression

To examine the direction and extent of behavioral predictors in explaining monthly electricity consumption and their variation across residential households (H4 and H5), we used a combination of exploratory factor analysis and multivariate linear regression methods. By combining the data from the periodic surveys and monthly utility records for electricity consumption of 155 single-family residential households, we constructed a panel dataset for our analysis with a maximum of 2891 and a minimum of 1039 observations for different variables.

4.2.1. Exploratory factor analysis

Before proceeding with the multivariate linear regression analysis, we used exploratory factor analysis with orthogonal (Varimax) rotation to identify latent constructs underlying EE and EC behaviors. Factor analysis uses an iterative process to express the common variance among the original variables in terms of a smaller set of latent variables (factors). Orthogonal (Varimax) rotation preserves the original orientation between the factor axes and maximizes factor simplicity [95,96]. We used Kaiser's criterion to identify and retain factors with eigenvalues more than one so that the variance explained by the factors are not less than those of the original variables. The identified factors corresponded fairly well with the underlying constructs of identity, appliance knowledge, and moral obligation, explaining >88 % of the total variation in

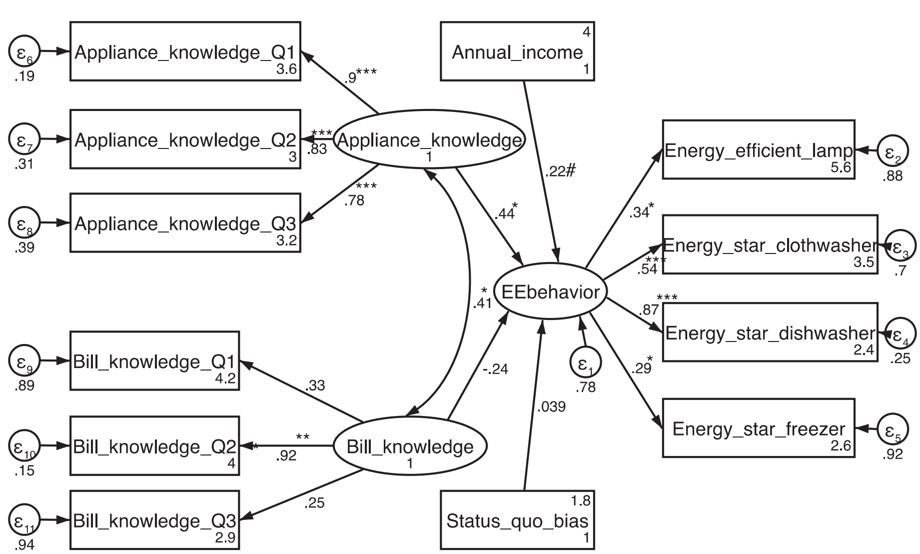

Fig. 4. Stata output showing Path diagram and results of SEM analysis for the reported EE behavior.

the data.

The rotated factor loadings with unique variances are shown in Table 2 below with values > 0.6 highlighted for comparison. We checked for sample adequacy using the Kaiser-Meyer-Olkin (KMO) measure and found the value to be 0.69, which is well above the required cutoff value of 0.50 [97]. We also checked for adequate correlation between the variables using the Bartlett test of sphericity and found the p value to be lower than 0.001 suggesting significant relationship [98].

4.2.2. Residential electricity conservation behavior using multivariate regression

With three latent factors identified from the factor analysis, we controlled for the demographic and socio-economic profile of households by including independent variables like average age, number of residents, household income, floor area, and home built year. We tested the effects of status-quo bias and values separately in the regression model. To take into account the impact of COVID-19 on total energy consumption, we used a dummy variable differentiating the period before and after March 31, 2020 in Model 5. Table 3 below displays the summary statistics of the variables used in our models.

The combined regression results from these models are summarized in Table 4 below. In models 1, 3, and 5 we used actual monthly electricity consumption as dependent variable. For models 2 and 4, we used the difference in monthly electricity consumption with respect to the average as the dependent variable. To test Hypotheses H4 and H5 on the role of reported EE and EC behaviors on total electricity consumption, we included the behavioral variables in models 3 and 4.

For the multivariate regression, we found the model to be significant at $p < 0.001$. We also find a small but significant increase in monthly electricity consumption due to shelter-in-place orders caused by the COVID-19 pandemic. In line with theoretical expectations, the pro-environmental identity and pro-environmental values variables are negatively related to the monthly electricity consumption as compared with the average among study participants. Whereas status quo bias was negatively related to energy consumption, the effects of moral obligation and home ownership were not significant. Overall, annual income had a negative impact on energy consumption. Further, the effects of floor area, numbers of household members, average age, house vintage, and political views were positively related to the monthly electricity consumed at $p < 0.05$.

5. Discussion

We note that due to the unforeseen events caused by the outbreak of COVID-19 during the study period, some survey responses and participation might have been impacted forming an important limitation of our study. There are other conceptual and methodological limitations to our study that need to be mentioned. First, our observational study design lacks the rigor of an experimental intervention suggesting correlation instead of cause-effect relationships [99]. Second, we studied residential energy savings primarily from the socio-economic and psychological perspectives, largely ignoring the influence of social and contextual practices that are not captured in the independent variables used in this analysis. Constrained by data availability, we used reported EC behaviors with modest Alpha values and single-response predictors for the pro-environmental values and status-quo bias variables. Third, we overlooked the heterogeneity and dynamics of energy behaviors within residential households [82]. Fourth, our single question measure adapted from previous literature might not adequately reflect the status-quo bias variable. Finally, our study relies on a relatively small and fairly homogenous sample from the suburban population in the Midwestern U.S. that is not nationally representative.

Despite the above limitations, we find consistent results across models on the strength of a sufficiently long monthly panel dataset over three years. We find a significant and consistent role of pro-environmental identity and value variables in influencing reported EC behaviors and reduced monthly energy consumption supporting the previous findings [11,59]. This broadly supports our Hypotheses 1 and 4 with the caveat that the identity and obligation variables might have significant overlaps. Although reported awareness about the billing, appliances, and energy knowledge, in general have been considered potential factors in reported EE behaviors [6], we could not find clear and consistent evidence of their influence on the total energy consumption. In this respect, our results are in line with earlier studies that suggest mere knowledge and awareness about the technological options may not be sufficient in bridging the value-action gap in energy conservation behavior [4,79]. Limited by the single variable question wording, our findings on the status quo bias variable is contrary to expectations [61], and will have to be explored further. However, we could

Table 2
Rotated factor loadings (pattern matrix) and unique variances sorted.

Variable	Factor1 (Identity)	Factor2 (Awareness)	Factor3 (Obligation)
Identity_Q1	**0.8783**	0.129	0.27
Identity_Q2	**0.9292**	0.1597	0.1796
Identity_Q3	**0.9019**	0.1397	0.1761
Appliance_knowledge_Q1	0.2548	**0.8607**	0.0592
Appliance_knowledge_Q2	0.1336	**0.8556**	0.0821
Appliance_knowledge_Q3	0.1636	**0.7192**	0.0737
Appliance_knowledge_Q4	0.0296	0.5286	−0.0062
Obligation_Q1	0.3184	0.0084	**0.8277**
Obligation_Q2	0.267	0.1665	**0.7791**
Obligation_Q3	0.3849	0.0388	**0.6793**
Bill_knowledge_Q3	0.1915	0.3461	0.0433
Bill_knowledge_Q1	−0.0074	0.3453	−0.1155
Status_quo_bias_Q2	−0.0626	0.0166	−0.0185
Status_quo_bias_Q1	0.0292	0.0519	0.0101
Status_quo_bias_Q3	0.0063	−0.1919	−0.0904
Bill_knowledge_Q2	0.001	0.0399	−0.0571

Table 3
Summary statistics of the key variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Monthly consumption (kWh)	2891	764	472	93	4254
Month wise difference (kWh)	2891	0.07	437.23	−1058.47	3584.04
Home built year (NRE_yearmade)	2831	4.38	2.14	1	8
Annual income (Annual_income)	2754	6.06	2.05	1	9
Total area (NRE_sqft)	2836	2040	725	400	5000
Average age (Average_age)	2891	44.16	10.68	23	75
Political views (NDE_ego_polview)	2632	3.58	0.82	1	5
Home ownership (Homeowner)	2891	1.06	0.24	1	2
Number of residents (DE_numresid)	2891	3.15	1.32	1	6
Kids in households (Kids)[a]	2517	0.556	0.497	0	1
Estimated Factor1 (Identity)	1860	0.08	0.88	−3.41	1.58
Estimated Factor2 (Awareness)	1860	0.03	0.94	−1.89	1.79
Estimated Factor3 (Obligation)	1860	0.03	0.87	−2.70	1.42
Status-quo bias (Status_quo_bias_Q2)	1860	2.34	1.36	1	5
Values (DE_values09)	1840	2.39	0.52	1	3

[a] Based on suggestion from one of the anonymous reviewers, we introduced presence of kids in the household as one of the variables in the equation and found it to be significant for the models 3 and 4.

Table 4
Multivariate linear regression results.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
	(Monthly consumption)	(Month wise difference)	(Monthly consumption)	(Month wise difference)	(Monthly consumption)
Home built year	3.33	3.49	16.09**	15.27**	
(NRE_yearmade)	(3.74)	(3.11)	(5.87)	(4.79)	
Annual income	−21.48***	−21.67***	−13.38*	−15.23**	
(Annual_income)	(5.04)	(4.23)	(6.79)	(5.81)	
Home area (NRE_sqft)	0.17*** (0.015)	0.17*** (0.014)	0.18*** (0.018)	0.18*** (0.017)	
Political views	16.16	13.16	51.91*	52.25*	
(NDE_ego_polvw)	(10.14)	(8.73)	(23.92)	(20.97)	
Average age	4.88***	4.92***	3.88*	3.97**	
(Aveage)	(0.87)	(0.78)	(1.56)	(1.39)	
Number of members	92.94***	94.05***	136.16***	136.95***	
(DE_numresid)	(7.66)	(6.29)	(18.00)	(14.98)	
Kids in households (Kids)	19.36 (22.38)	17.38793 (19.71)	−202.2652*** (34.36)	−207.194*** (29.99)	
Pro-environmental			−50.19*	−49.92*	
(Identity)			(22.24)	(19.47)	
Appliance knowledge			1.91	−1.03	
(Awareness)			(15.02)	(13.42)	
Moral obligation (Obligation)			−0.91 (16.14)	−0.62 (15.12)	
Home ownership			8.94	6.18	
(Homeowner)			(55.07)	(47.45)	
Value (DE_values09)			73.17**	66.67**	
			(26.90)	(23.17)	
Status-quo bias (Status_quo_bias_Q2)			−37.52*** (10.74)	−39.55*** (9.73)	
Dummy variable (Dcovid)					91.67*** (14.51)
Constant	−58.43	−812.0***	−411.2*	−1153.4***	736.8***
	(78.39)	(67.92)	(180.73)	(152.35)	(7.606)
Observations	2126	2126	996	996	2891
R-squared	0.16	0.19	0.21	0.27	0.014
Number of entities					155

Robust standard errors are in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

not detect a distinct and significant effect of homeownership or reported billing knowledge or appliance awareness on the total electricity consumption of the households.

In line with previous studies [13,19], we find that the number of members and their average age positively and significantly affect household electricity consumption. However, the relationship may not be additive and straightforward as we find that presence of kids in the family relates negatively with the overall electricity consumption. In sum, our findings suggest that the household size and family life cycle together affect the electricity consumption in a non-linear and interactive manner supporting the arguments in [30,78] that will need to be studied further. An interesting outcome of our analysis is regarding the effect of annual household income on the reported EE and EC behaviors and their overall impact on the total electricity consumption. In line with the earlier findings by Umit et al. [19], we find a negative and significant relationship between income and reported EC behaviors. In agreement with previous studies [6,18], we also find annual income to be positively and marginally significant in affecting the reported EE behaviors. Our findings from the apparently divergent role of household income on the EC and EE behaviors suggest that low-income households are more likely to engage in curtailing energy services in comparison to the energy-efficient high-income households. In such situation, uniform application of EE policies will not only leave out low-income population but can also perpetuate the unjust cost burdens further [100,101]. For equitable policy design, it will be important to take into account the heterogeneity in population groups depending on their income, energy behaviors, and existing energy burden [13,102,103].Overall, our results suggest that annual incomes are negatively related to the total monthly electricity consumption of the households. This might be due to the specific demographic profile of the chosen respondents from suburban US households. Another possible reason for this outcome could be due to the positive and larger influence of annual income on the reported EE behaviors over and above their negative influence on the reported EC behaviors. However, this finding will have to be tested further on a larger scale in future studies.

The R-squared values across the models suggest a significant role of the combined effects of the behavioral predictors in residential energy conservation behaviors. We not only find the R-squared values to be consistently higher when the behavioral predictors are included in the models but also observe that their combined effects are magnified when the difference in energy consumption is used in the models as the dependent variable. Overall, our results suggest that the behavioral factors underlying the EC and EE behaviors in terms of the moral obligation, pro-environmental identity, and the status quo bias together significantly account for the total electricity consumption compared to their average across the households. We argue that it will not be sufficient to understand and rely on EE or EC behaviors separately. Rather, the residential energy conservation policies will have to be carefully designed with a better understanding of the underlying factors of the two behaviors acting together. Our findings not only provide empirical support to the literature on the role of behavioral factors in understanding the residential EC and EE behaviors individually but also highlight the need for understanding their distinct and combined role in limiting the overall energy consumption and carbon emissions from a sustainable energy policy perspective [104].

6. Conclusion

Understanding complex energy-saving behaviors is important for tailored, targeted, and effective energy conservation policies. In the field of residential energy conservation, behavior change programs relying on information (e.g., home energy reports, feedback, and energy audits), social interactions (e.g., games and community-based programs), and education are being increasingly considered as potential policy options in reducing energy consumption at a lower intervention cost [107]. However, the nature and extent of underlying explanations of such behavioral interventions are not yet settled satisfactorily, requiring further study.

Due to the complexity and dynamic nature of residential energy conservation actions involving changes in household behavior, there is a need for multi-disciplinary studies that inform and suggest multiple policy options from diverse analytical frames [12,106,107]. The study of residential energy conservation behaviors from diverse academic perspectives is not only considered important for correct intervention design, but also helpful in evaluating their overall societal impacts. A recent study notes that the way these diverse concepts are applied to the real world involves a value judgment with consequences on societal trade-offs that are less clearly understood, and applying any given conceptualization can privilege certain interests over others, affecting society in multiple different ways [108]. Despite the extensive literature suggesting the important role of the underlying behavioral factors, conclusive evidence supporting energy conservation actions is lacking due to their reliance on isolated theoretical perspectives, assumptions of monocausal relationships, and indirect methods that have not been tested empirically on a large scale.

To address these gaps, we used a mix of theoretical approaches and analytical methods to empirically test the role and extent of some of the behavioral factors underlying energy conservation using actual electricity consumption data. Our study is a modest but novel attempt to analyze residential energy consumption using an inter-disciplinary approach with predictors from the behavioral economics and environmental psychology literatures. Despite the theoretical and methodological limitations of the study, our empirical findings suggest a consistent and significant correlation between behavioral predictors and residential energy consumption. This analysis not only highlights the role of personal identities, pro-environmental values, and awareness in affecting reported energy behaviors and household electricity consumption but also suggests significant overlaps between these variables at different levels. Our empirical analysis supports the need for studying the distinct yet combined roles of the EC and EE behaviors in total residential energy consumption that are often lumped together in the literature. For net energy savings, it may not be sufficient to understand and rely on EE or EC behavior alone. For better outcomes, policies integrating these two behaviors can be designed and tested. An important observation from our analysis concerns the differentiated role of annual income in mediating the EE and EC behaviors with important policy implications for equitable distribution of energy efficiency benefits and burden. It also suggests that the socio-economic and psychological variables are related in multiple ways that cannot be fully explained by linear, unidirectional, and monocausal relationships.

For achieving sustainable energy policy objectives, there is a need for analyzing the residential energy consumption from multi-disciplinary perspectives that complement the behavioral attributes with techno-economic considerations. Future studies can build upon these findings. We believe that our analysis not only contributes to the ongoing discussion on the role and extent of predictors of residential energy consumption behaviors but can also inform future intervention designs with significant implications for sustainable energy policies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A

Table A1
Path coefficients, *p* values, Std, errors, and Model fitness indices from the SEM analysis for EC behavior.

	Std. path coefficients	Std. error
Path		
Average age (Aveage) → ECbehavior	0.10**	(0.86)
Annual income → ECbehavior	−0.18*	(0.08)
Identity → ECbehavior	0.25*	(0.13)
Obligation → ECbehavior	0.05	(0.13)
ECbehavior → Often programs thermostat (ECbehavior_Q1)	0.36*	(0.08)
ECbehavior → Sets lower temperature for heater in winter (ECbehavior_Q2)	0.88***	(0.06)
ECbehavior → Sets higher AC temperature in summer (ECbehavior_Q3)	0.82***	(0.06)
ECbehavior → Often dries clothes on line (ECbehavior_Q4)	0.20*	(0.09)
ECbehavior → Often turns off lights when not present (ECbehavior_Q5)	0.28*	(0.08)
ECbehavior → Often wash clothes in cold water (ECbehavior_Q6)	0.12	(0.09)
Identity → Acting environment friendly important part (Identity_Q1)	0.93*	(0.01)
Identity → Acts environmentally friendly (Identity_Q2)	0.97***	(0.08)
Identity → Type of person that benefits environment (Identity_Q3)	0.94***	(0.01)
Obligation → Feel morally obliged to conserve energy (Obligation_Q1)	0.90*	(0.03)
Obligation → Feel guilty if not take actions to conserve energy (Obligation_Q2)	0.87*	(0.03)
Obligation → Feel proud to conserve energy (Obligation_Q3)	0.75*	(0.04)
Covariance (Identity, Obligation)	0.66***	(0.05)
Model fitness		
Model vs saturated Likelihood ratio chi^2_ms (73)	93.27	0.05
chi2_bs (90)	1026.96	0.000
Root mean squared error of approximation (RMSEA)	0.046	
Probability RMSEA ≤ 0.05	0.587	
Comparative fit index (CFI)	0.978	
Tucker-Lewis index (TLI)	0.973	
Standardized root mean squared residual (SRMR)	0.068	
Coefficient of determination (CD)	0.995	

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table A2
Path coefficients,p values, Std. errors, and Model fitness indices from the SEM analysis for EE behavior.

	Std. path coefficients	Std. error
Path		
Status quo bias (Status_quo_bias) → EEbehavior	0.039	(0.162)
Annual income (Annual_income) → EEbehavior	0.22#	(0.158)
App_knowledge → EEbehavior	0.44*	(0.20)
Bill_knowledge → EEbehavior	−0.24	(0.21)
EEbehavior → Owns energy efficient light bulbs (Energy_efficient_lamp)	0.34*	(0.17)
EEbehavior → Owns energy star freezer (Energy_star_freezer)	0.29*	(0.15)
EEbehavior → Owns energy star dishwasher (Energy_star_dishwasher)	0.87***	(0.17)
EEbehavior → Owns energy star washing machine (Energy_star_clothwasher)	0.54***	(0.15)
App_knowledge → Knowledge of energy star appliances (Appliance_knowledge_Q1)	0.90***	(0.05)
App_knowledge → Knowledge of water efficient appliances (Appliance_knowledge_Q2)	0.83***	(0.61)
App_knowledge → Knowledge of energy star appliances (Appliance_knowledge_Q3)	0.78***	(0.07)
Bill_knowledge → Check utility bills online (Bill_knowledge_Q1)	0.33	(0.17)
Bill_knowledge → Find utility bills easy to understand (Bill_knowledge_Q2)	0.92**	(0.33)
Bill_knowledge → Can assess bill from energy meter (Bill_knowledge_Q3)	0.25	(0.19)
Covariance (App_knowledge, Bill_knowledge)	0.41*	(2.11)
Model fitness		
Model vs saturated Likelihood ratio chi^2_ms (81)	36.673	0.925
chi2_ms (95)	141.87	0.000
Root mean squared error of approximation (RMSEA)	0.000	
Probability RMSEA ≤ 0.05	0.971	
Comparative fit index (CFI)	1.000	
Tucker-Lewis index (TLI)	1.230	
Standardized root mean squared residual (SRMR)	0.079	
Coefficient of determination (CD)	0.983	

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
# $p < 0.2$.

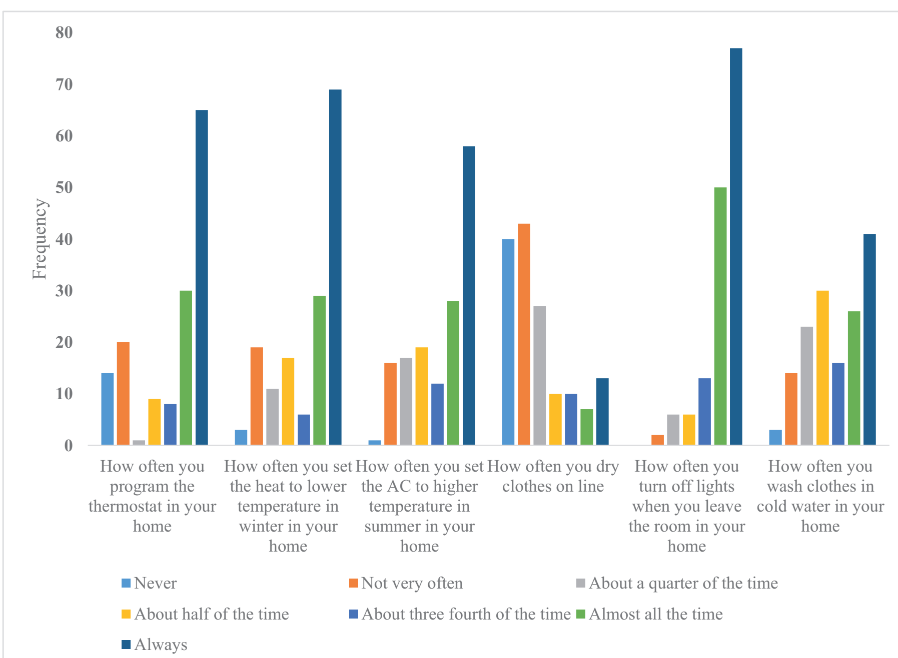

Fig. A1. Frequency distribution of the survey responses on energy conservation behavior (ECbehavior).

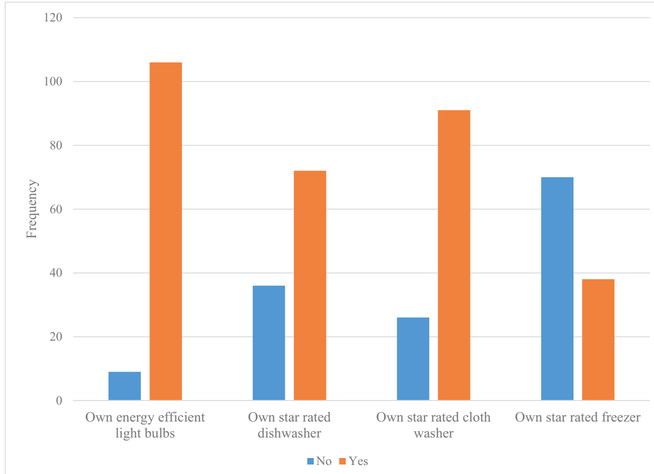

Fig. A2. Frequency distribution of the responses to the survey questions on energy efficiency behavior (EEbehavior).

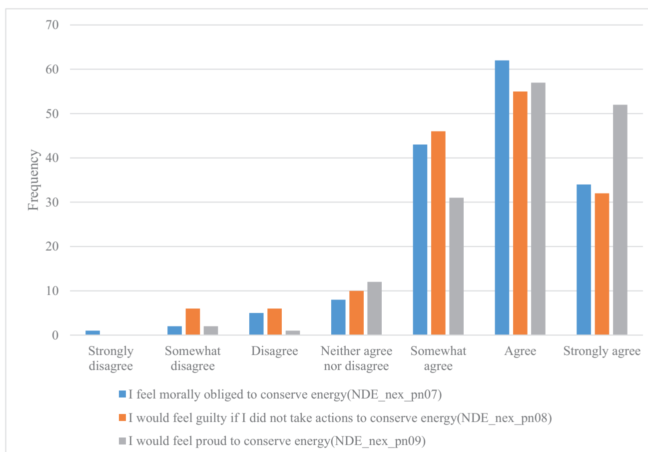

Fig. A3. Frequency distribution of the responses to the survey questions on moral obligation (Obligation).

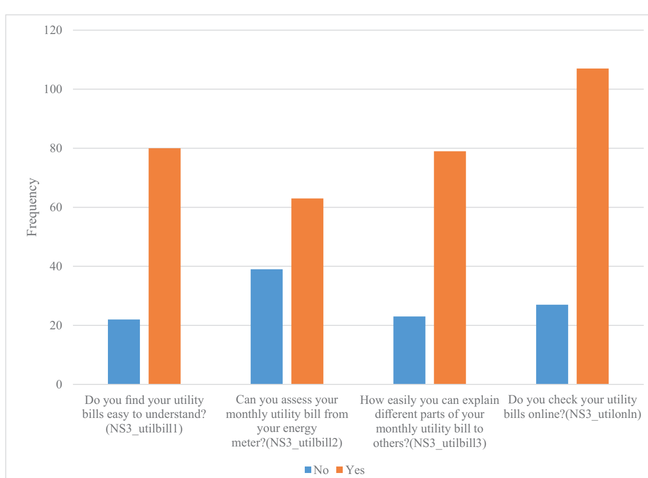

Fig. A4. Frequency distribution of the responses to the survey questions on billing awareness.

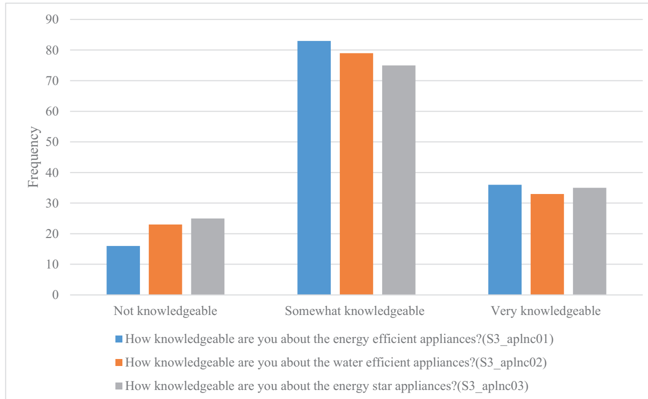

Fig. A5. Frequency distribution of the responses to the survey questions on appliance knowledge.

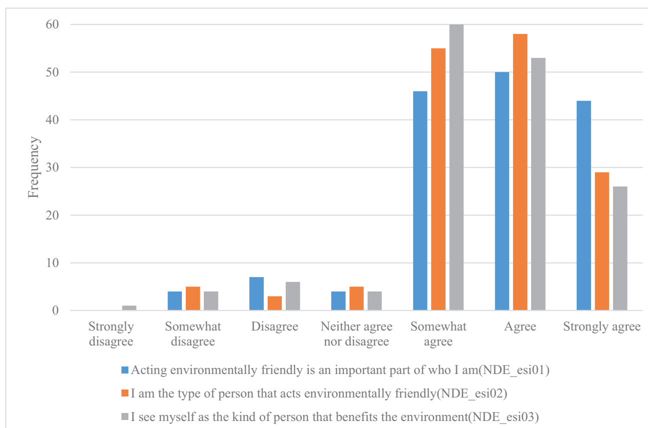

Fig. A6. Frequency distribution of the responses to the survey questions on pro-environmental identity (Identity).

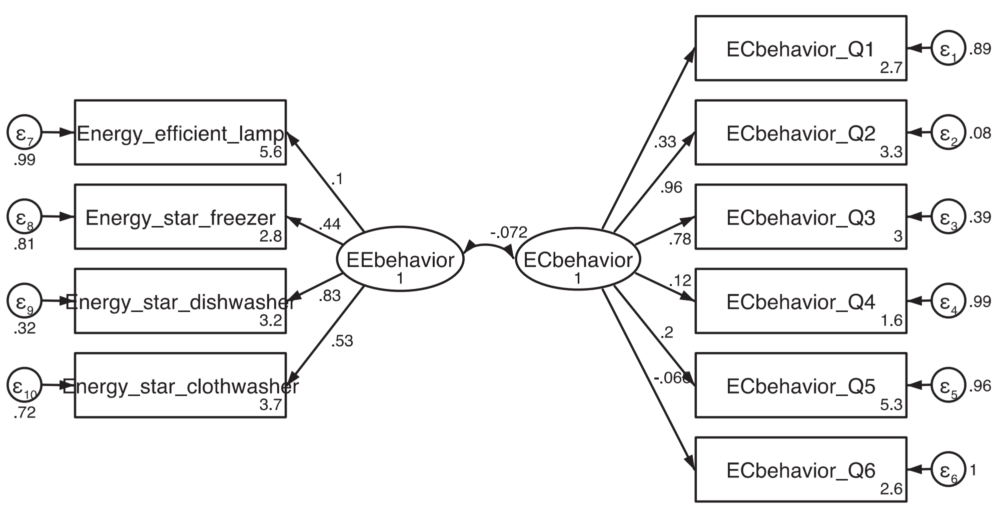

Fig. A7. Path diagram for testing overlap between EE and EC behaviors.

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