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Review

The Socio-Demographic and Psychological Predictors of Residential Energy Consumption: A Comprehensive Review

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Abstract: This article provides a comprehensive review of theory and research on the individual-level predictors of household energy usage. Drawing on literature from across the social sciences, we examine two broad categories of variables that have been identified as potentially important for explaining variability in energy consumption and conservation: socio-demographic factors (e.g., income, employment status, dwelling type/size, home ownership, household size, stage of family life cycle) and psychological factors (e.g., beliefs and attitudes, motives and intentions, perceived behavioral control, cost-benefit appraisals, personal and social norms). Despite an expanding literature, we find that empirical evidence of the impact of these variables has been far from consistent and conclusive to date. Such inconsistency poses challenges for drawing generalizable conclusions, and underscores the complexity of consumer behavior in this domain. In this article, we propose that a multitude of factors—whether directly, indirectly, or in interaction—influence how householders consume and conserve energy. Theory, research and practice can be greatly advanced by understanding what these factors are, and how, when, where, why and for whom they operate. We conclude by outlining some important practical implications for policymakers and directions for future research.

Keywords: review; energy consumption; energy conservation; household energy use; pro-environmental behavior; psychology; motivation; behavior change

1. Introduction

In recent years, a growing body of research has sought to identify the key factors underlying patterns of residential energy consumption and conservation. In particular, many studies have been conducted to investigate different types of energy consumer "profiles" in an effort to pinpoint precisely what factors are associated with energy-saving and energy-wasting behavior (e.g., [1–5]). A number of important determinants have been identified, ranging from situational factors in the external environment (e.g., contextual, structural and institutional factors) through to more person-specific attributes of consumers themselves (e.g., socio-demographic, psychological and motivational factors) [6–12]. Yet efforts to summarize, integrate and synthesize the key findings across studies have failed to keep pace. The current paper addresses this gap by conducting a comprehensive review of published research on the socio-demographic and psychological determinants of household energy consumption and conservation. In the literature, behaviors related to energy conservation are sometimes categorized into "curtailment" behaviors (*i.e.*, ongoing day-to-day actions to reduce consumption, such as setting thermostats, switching off lights, limiting use of heating/cooling and ventilation systems, *etc.*) and "efficiency" behaviors (*i.e.*, once-off actions to save energy, such as investing in home improvements like insulation, solar panels, energy-efficient appliances, new technology, *etc.*) [13,14]. In this article, we focus on both categories of energy usage behavior. By doing so, we aim to provide researchers, practitioners and policymakers with a deeper understanding of what person-specific factors might explain different patterns of household energy usage, and thereby provide valuable insights on when, where, how, why and for whom energy-efficient interventions might serve to promote and sustain new energy-conserving practices.

Advancing our understanding of the key factors shaping consumers' energy-related behavior is important for many reasons. Against a backdrop of global concerns over climate change and rising greenhouse gas emissions, renewable and sustainable energy use has become a key challenge and opportunity for improving the overall social-ecological resilience of communities worldwide. Globally, researchers and policymakers are investing significant resources in designing cost-effective solutions and new technology to increase household energy efficiency and conservation. Yet there is vast scope for improvement, as reflected by recent calls for greater integration of social and behavioral sciences in energy research [15]. Solving many of the world's energy-related problems requires not only technological advances, but also changes in human behavior—and successfully shifting the behavior of consumers in the desired direction (*i.e.*, toward more efficient and sustainable practices) is facilitated by first identifying potential causal and explanatory variables (predictors and "mediators") and various contingencies (interactions or "moderators") that might impact the nature, intensity, frequency and duration of behavior across time and contexts.

So why is it important to identify the correlates of energy consumption and conservation? The answer is simple: to know how to intervene, and with whom, where and when. It is necessary to understand what drives household energy consumption and conservation in order to determine how these behaviors can usefully be altered by consumer-focused interventions, technological solutions, public policy initiatives and other such strategies.

In an effort to integrate key insights from the literature, our paper begins by providing a theoretical overview of residential energy usage, with a focus on describing how the processes and predictors of

energy consumption and conservation have been conceptualized to date. Drawing heavily on published work from the social and behavioral sciences, we then review research and empirical evidence on the individual-level predictors of household energy use in an effort to identify the key characteristics and variables that explain consumers' energy-related behavior. This includes a review of the major socio-demographic factors that have been touted as explaining individual differences in household energy consumption and conservation, as well as the psychological and motivational attributes of consumers that have also been hypothesized to play a role. We review publications that present both primary and secondary research, and studies that employ a range of designs and methodologies. In outlining our key findings and conclusions, we provide a brief summary of research in the body of the article itself, with a more detailed review of empirical evidence and citations appearing in the accompanying table. Finally, we draw out the implications of our key findings for theory, research and practice, with a focus on identifying some cost-effective behavioral solutions to influence household energy consumption and conservation.

2. Theoretical Background: Conceptualizing Energy Consumption and Conservation

Over the past few decades, the factors underpinning individual differences in pro-environmental attitudes and behavior have been examined from a range of different theoretical perspectives (for reviews, see [16–20]). Due to the complex and dynamic nature of behavior in this domain, a wide variety of conceptual models have been hypothesized and countless studies have been conducted to investigate the variables influencing environmentally significant decision-making and action. Some of the most influential and commonly cited perspectives, theories and models of pro-environmental behavior include: Hines *et al.*'s [21] model of responsible environmental behavior; Ajzen's theory of planned behavior [22,23]; Guagnano *et al.*'s [24] attitude-behavior-external conditions (ABC) model; Stern *et al.*'s [25] value-belief-norm (VBN) theory; Blake's [26] conceptualization of the barriers between environmental concern and action; Stern's [19] framework of environmentally significant behaviors and causal variables; and Kollmuss and Agyeman's [20] model of pro-environmental behavior.

This theoretical research from the broad domain of pro-environmental behavior has extended to the more specific area of residential energy conservation, with recent years witnessing an increased focus on identifying the specific factors that influence household energy usage (e.g., consumption) and changes in energy use over time (e.g., curtailment and efficiency behaviors) [6,13,14,27]. An exhaustive summary of all relevant theories, frameworks and conceptual models of household energy use is beyond the scope of this paper. However, some of the most influential and commonly cited approaches include: Van Raaij and Verhallen's [8] behavioral model of residential energy use; Costanzo *et al.*'s [10] socio-psychological model of energy conservation behavior; and Stern and Oskamp's [28] causal model of resource use. Some researchers have also applied Hägerstrand's [29,30] time-geographic approach to study household energy-related activities [31,32]; and Schatzki's [33] practice theory to study the unconscious habits and technological structures that influence residential energy consumption [34,35]. Rogers' [36,37] diffusion of innovations theory has also been used to explain consumers' decision-making and behavior in the context of residential energy consumption, specifically in terms of the adoption of energy-saving practices and products [38–42].

While various theoretical perspectives have emerged in the literature, there is no single conceptual framework or model that is universally accepted by scholars as providing an all-inclusive explanation of energy consumption and conservation, nor any single approach that precisely predicts individual differences in such behavior. Rather, the extant literature seems to indicate that the issue of what distinguishes above- and below-average energy users—or "energy-wasting" and "energy-saving" consumers—is so complex that it is difficult to capture in a single framework [20,21]. Further, while empirical evidence indicates that some variables may be better predictors of energy consumption than others, the findings have still been far from consistent across time, contexts, samples of participants, and studies. This inconsistency may be partly an artifact: due to energy-related "behavior" being conceptually and operationally defined in different ways—for example, it can be measured in terms of overall household energy consumption (e.g., kilowatts per hour usage), changes in specific everyday practices (e.g., curtailment actions), or adoption of certain energy-efficient technology (e.g., efficiency actions), among many others. And the role of different explanatory variables can appear to vary depending on exactly how a "behavior" is defined and measured, and the relationships specified (or "allowed") in the model. The inconsistency may also be due to the fact that very few studies have rigorously tested causal relationships using the appropriate scientific methodology (*i.e.*, randomized controlled trials), with many relying on non-experimental designs that can only explore correlations between variables. In the absence of well-designed, consistently specified, and rigorously conducted empirical research, it is impossible to draw firm conclusions regarding the precise causal impact of certain factors on energy consumption and conservation.

Nevertheless, several researchers have made progress with integrating different perspectives in a bid to advance the literature and resolve inconsistent findings [14,43–45]. This effort has yielded some clarity and there is now general agreement that several broad yet interrelated categories of variables may explain individual differences in household energy use. These explanatory variables include a range of socio-demographic factors (e.g., income, education, household size, dwelling type, stage of family life cycle), psychological factors (e.g., knowledge, values, attitudes, motivations, intentions, social norms) and external contextual and situational factors (e.g., socio-cultural, economic, political, legal, institutional forces), among others.

The literature now features models that better articulate the multiplicity of forces underpinning energy consumption and conservation. In early research, Costanzo *et al.* [10] proposed a social-psychological model of energy conservation consisting of two interacting sets of factors: psychological (*i.e.*, factors shaping consumers' information-processing and decision-making, such as perception, evaluation, understanding and memory) and positional/situational (*i.e.*, factors that facilitate or constrain consumers' actions, such as disposable income, home ownership, home repair skills, and own-home technology). More recently, Abrahamse *et al.* [14] proposed that both micro-level factors (e.g., preferences, attitudes, values, abilities, opportunities) and macro-level factors (e.g., availability of new technology, economic and population growth, government regulations and policies, socio-cultural change) can influence household energy consumption. Kollmuss and Agyeman [20] have also distinguished multiple influences of pro-environmental behavior, such as demographic factors (e.g., gender, years of education), external factors (e.g., social, cultural, economic, institutional), and internal factors (e.g., motivation, environmental knowledge, awareness, values, attitudes, emotion, locus of control, responsibilities, priorities). Similarly, Stern [19] has proposed that environmental behavior is shaped

by a range of attitudinal variables (e.g., general environmentalist predisposition, behavior-specific norms and beliefs, perceived costs/benefits, non-environmental attitudes), personal capabilities (e.g., literacy, social status, financial resources, behavior-specific knowledge and skills), contextual factors (e.g., social norms and expectations, material costs/rewards, available technology, advertising, and laws, policies and regulations), and habits and routines.

Over the years, researchers have increasingly favored these integrative approaches, which view energy consumption and conservation as arising from an ongoing interaction of multiple factors (e.g., [10,14,19,20]). We follow this approach by conceptualizing household energy usage as a complex process with a range of predictors—including both individual and situational factors, and their interaction—that jointly influence the energy-related practices and behavior of households (Figure 1).

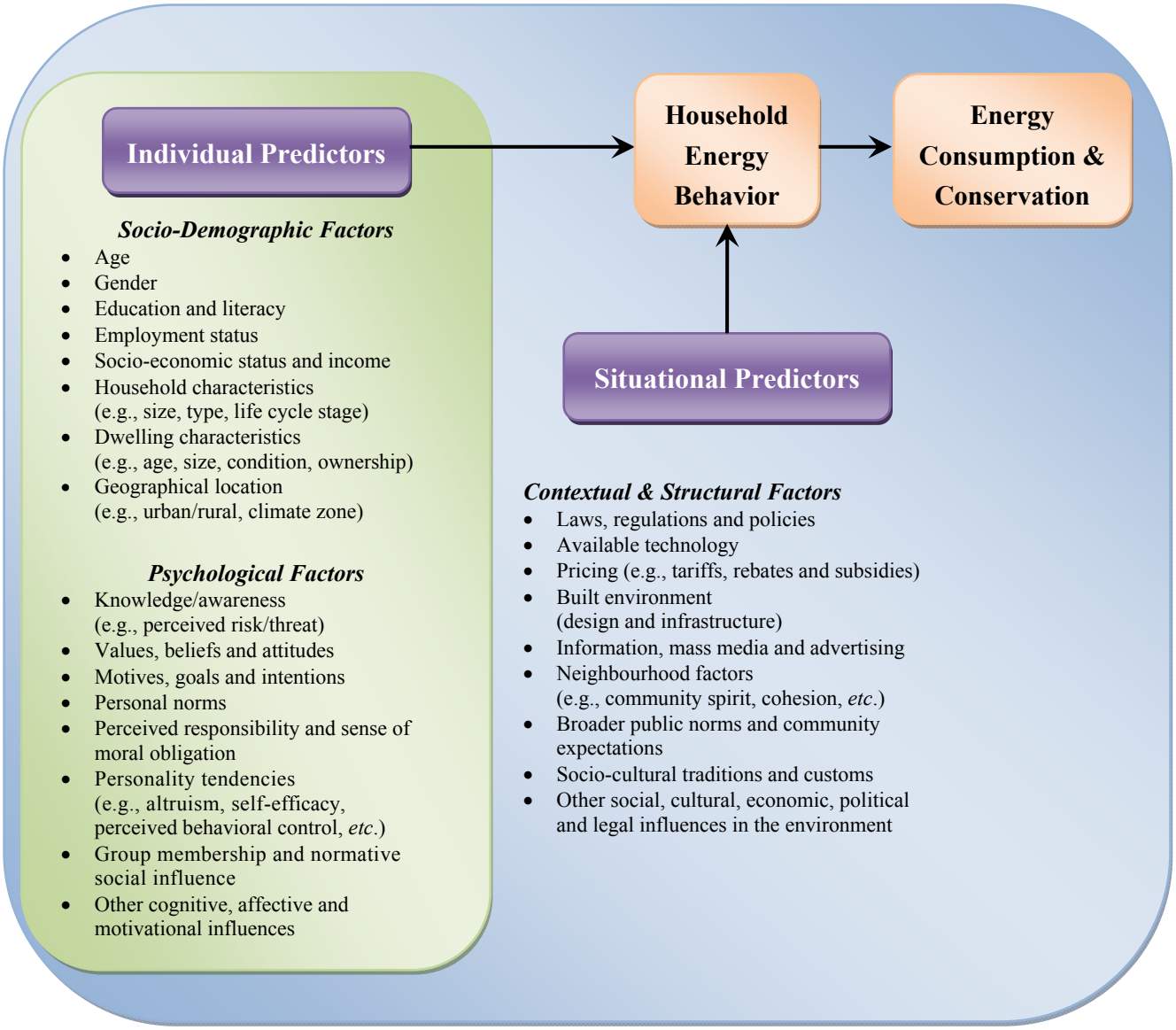

Figure 1. Integrative conceptualization of the various individual (socio-demographic and psychological) and situational (contextual and structural) factors that may influence household energy consumption and conservation.

While we use this integrative conceptualization as our overarching framework for understanding energy consumption and conservation, our review only centers on a subset of factors from the framework: the individual-level predictors of household energy use. This is in keeping with traditional psychological perspectives of pro-environmental behavior, which focus primarily on person-specific factors.

3. The Current Review

3.1. Focus and Scope of the Review

While not discounting the important role of contextual and situational factors, this paper will focus squarely on reviewing the most commonly-examined individual factors correlated with household energy consumption and conservation. Comparatively less emphasis will be placed on macro-level predictors in the broader environment, which are often social, technological and institutional constraints that prevent householders from acting (or enable householders to act) in a certain way regardless of their particular socio-demographic features, psychological attributes and other person-specific characteristics. For example, contextual forces such as government regulations, public policies and other aspects of the broader social, cultural, economic, and political environment (e.g., public infrastructure, electricity prices, government sensitivity to public and interest group pressures, mass media, advertising campaigns, financial markets) can influence patterns of household energy usage, often independent of any individual-level influences. These macro-level factors may also place constraints on policymakers, who are faced with making public policy decisions about the energy industry and consumers within relatively fixed societal and institutional boundaries. While it is important to recognize the potential impact of these contextual factors, they fall outside the scope of this review, whose focus is on first elucidating the individual (*i.e.*, human behavior) part of the equation. Nonetheless, many of the individual variables discussed herein inherently reflect the interface between people and their environment, to the extent that such factors are inextricably linked with one another (as in the case of normative social influence, for example).

3.2. Procedure for the Review

A rigorous process was followed to identify relevant literature for this review. First, a systematic search of the academic literature was undertaken using a number of bibliographic databases in the social, behavioral and environmental sciences (e.g., PsychINFO, ScienceDirect, SpingerLink, Wiley Online Library), as well as other internet search engines and online resources. Subject headings and keywords used in the search process included: residential energy consumption, residential energy conservation, household energy consumption, household energy conservation, and household energy use. Publications from the domains of energy, industry and the built environment were also examined. As part of this literature search process, the reference lists, bibliographies and citations of retrieved literature were also scanned for additional sources. We confined our search to studies conducted in Western countries, written in English, and published since the late 1970s. Evidence from non-western contexts was excluded due to potentially significant and consequential differences in the socio-demographic and psychological determinants of residential energy usage in less developed countries. Studies conducted before the 1970s were also excluded due to concerns about their applicability and

generalizability to contemporary contexts (many patterns and predictors of household energy use may have changed over the past 40 years). Our overriding objective was to draw valid conclusions for current contexts and consumers; up-to-date knowledge and insights are essential for devising cost-effective and readily scalable solutions to contemporary energy-related challenges.

In conducting our review, we examined both primary and secondary evidence, and included studies with a wide range of research designs and methodologies. To make our review as comprehensive as possible, we considered not just studies where socio-demographic and psychological factors were the focal variables of interest, but also those that shed light on such factors incidentally, as a by-product of the primary analyses, as well as publications that usefully synthesized earlier findings. While our primary objective was to review published research in the specific domain of household energy usage, we also considered key insights from the broader domains of pro-environmental behavior (e.g., conservation activities) and resource usage (e.g., consumption), as well as empirical findings regarding the psychology of human behavior more generally. Our systematic review of the literature ultimately identified a large number of journal articles, books and book chapters, working papers, conference proceedings and reports—which in totality formed the basis for the key findings and conclusions presented herein.

3.3. Structure of the Review

In the sections that follow, we summarize the key findings from our comprehensive review of the literature, first for socio-demographic predictors and then for psychological factors. While a range of variables have been hypothesized to explain variation in household energy consumption and conservation, we focus only on the individual-level factors most often touted as distinguishing "energy-wasting" from "energy-saving" consumers. Prior research suggests that residential energy use is more strongly related to socio-demographic variables, whereas changes in residential energy use over time are more dependent on psychological and motivational variables [27]. We summarize here the broad findings that have emerged to date for both categories of predictors. To maintain focus and clarity, the main body of this article presents only a concise summary of general findings, with the accompanying table furnishing a more comprehensive review of prior research—including sources of supporting evidence and full citations.

4. Overview of Key Findings

4.1. Socio-Demographic Predictors

As evident in the top portion of Table 1, household energy consumption and conservation are associated with a wide range of socio-demographic variables. The relatively unchanging opportunities and constraints that people confront when seeking to engage in certain activities may significantly influence how much energy a particular consumer or household can use at any moment in time. Socio-demographic factors such as household income, dwelling type and size, home ownership, family size and composition, and life cycle stage are just some of the many factors that may influence these opportunities and constraints, and thereby indelibly shape the amount, frequency and duration of a household's energy use. Our review of the literature reveals a good number of sources examining

the effects of standard socio-demographic factors like age, gender, income, home ownership and household size, but comparatively little assessment of variables such as householders' technical expertise and ownership of home technology. Despite considerable uncertainty introduced by the complex interactions that can occur between multiple factors over time (see the diversity of results evident in Table 1), some general findings to emerge regarding the socio-demographic predictors of energy usage include the following:

- There is inconsistent empirical support for age and gender differences in energy consumption, with any effects tending to be rather small and/or statistically insignificant.
- Education tends to be associated with increased knowledge, awareness and concern regarding environmental issues (such as energy efficiency), however, higher levels of education generally do not lead certainly and directly to pro-environmental behavior (e.g., saving energy).
- Employment status of household occupants (e.g., full-time, part-time, retired or unemployed) may indirectly impact energy consumption, by influencing household income and socio-economic status, which in turn can constrain the household's financial capacity to invest in efficiency measures. Links between occupational status and acceptance of energy-saving strategies have also been examined, but there is limited and inconsistent evidence that this strongly influences energy consumption.
- Household income tends to be positively related to residential energy consumption, but may also enhance household capacity to invest in products and improvements that increase energy efficiency (e.g., to purchase new appliances and more energy-efficient technology).
- Household size (number of people per residence) tends to be positively associated with energy consumption, such that larger families generally consume more energy overall. However, energy usage per capita tends to be lower in larger households, presumably due to the sharing of energy services among multiple residents.
- Dwelling size (floor space, number of rooms/floors, *etc.*) appears to be positively related to household energy consumption, with larger dwellings typically using more energy. Additionally, people residing in detached dwellings (free-standing homes and townhouses) tend to consume more energy than those in multi-unit dwellings (apartments and units).
- Homeowners tend to make larger capital investments in energy conservation measures (e.g., household improvements to increase energy efficiency, purchase of new technology and energy-saving devices) than those living in rental housing.
- Stage of family life cycle appears to be an important predictor of household energy use, with energy consumption typically peaking during the child-rearing years, presumably due to associated changes in household work (e.g., cleaning, cooking, laundry), childcare, and family activities (e.g., in-home entertainment, recreation). The presence or absence of family members—including changes in family composition over time (e.g., the birth of a baby, an older child leaving home)—may also influence levels and patterns of household energy consumption.

Table 1. Socio-demographic and psychological factors associated with household energy consumption and conservation.

Category	Predictor	Impact on household energy consumption and conservation behavior
Socio-demographic factors	Age	• Overall, age does not consistently emerge as a statistically significant predictor of household energy use. Some research supports a positive association between age and energy consumption, such that energy usage increases as the household head grows older. This may be because older people are less likely to adopt energy efficiency measures (given more negative perceptions of the likely cost/benefit ratio and return on investment), possess less knowledge of energy problems and solutions, have lower income and/or poorer home conditions, or require more cooling/heating than younger people to be comfortable [6,46–51]. However, this positive association is far from consistent, with many studies failing to detect any statistically significant effects of age [7,21,27,52,53] or even suggesting that older people are actually more likely to be energy-savers and committed to sustainable energy use (e.g., [1,43,54]). • Some studies have even proposed a curvilinear relationship with age, in various forms, where energy consumption peaks either (a) during the middle stages of the life cycle, perhaps with the larger households typical of mid-life having higher energy requirements [50,55], or conversely (b) for younger and older households, perhaps because both tend to live in smaller households with higher per capita consumption, and take fewer energy-saving actions than those in middle-age [56].
	Gender	• The effects of gender on household energy usage seem to be inconsistent, minimal or statistically insignificant. Some research seems to indicate that women exhibit more pro-environmental attitudes and behavior than men [20,43,57,58], while others find no significant relationship [6,21,27,51,59,60]. • It may be that gender differences in socio-economic conditions and lifestyles (e.g., exposure to poverty, child rearing responsibilities, *etc.*) sometimes constrain the ability of women to conserve energy [61,62]. However, gender-based differences tend to dissipate once one controls for the effects of confounding variables such as household size, income and even age [58].
	Education	• Some studies have reported significant effects of education on pro-environmental behavior and/or energy usage [7,46,63]. But increased education does not typically translate directly into more pro-environmental behavior per se [20]. Rather, across many domains of human behaviour there is often a "knowledge-action gap" [43,64–66], not only in terms of general pro-environmental behavior but also (more specifically) in regard to household energy consumption. • For example, several studies have found that education level has no significant impact on either the number of conservation activities [52,67] or household energy consumption [53,54]. While others have found more educated people are slightly more likely to display pro-environmental behavior, these effects are either statistically insignificant [21] or far weaker than the impact of socio-demographic, psychological and motivational factors that are more proximal to actual behavior [56].
	Employment status	• Type of employment (full-time, part-time, retired or unemployed) of household members—particularly the head of the household—may indirectly impact energy consumption by influencing the household's socio-economic status, confidence in income security and/or financial capability to invest in efficiency measures (e.g., new energy-saving technology).

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Socio-demographic factors	Employment status	• Consumers in full-time employment tend to have more disposable income to spend on day-to-day energy use and energy-intensive appliances, but also more money to invest in one-off energy-saving measures (e.g., solar panels, insulation, energy-efficient light bulbs). They also tend to spend fewer hours per day at home compared to part-time, retired or unemployed consumers, which may contribute toward less household consumption. Indeed, some research suggests that full-time employment is significantly related to making home improvements to conserve energy [47]. It has been proposed that compared to being retired, unemployed or even in part-time employment, full-time employment of the head-of-household may raise consumers' confidence in their capacity to undertake home improvements. • Some research has also found that people with higher-status occupations may be slightly more accepting of certain energy conservation strategies [60]; however, these effects have not been consistently observed (e.g., [67,68]) and as such, the influence of occupational status is unlikely to be strong and/or explain substantial variability in household energy consumption.
	Income	• Household income appears to be one of the strongest socio-demographic predictors of residential energy use and conservation. Most studies have found positive associations between household income and residential energy consumption, suggesting that higher-income households tend to consume more energy than lower-income households [6,7,27,53,54,69–72]. At the same time, however, there is also evidence that higher-income households may be more willing and/or able to conserve energy because they can afford the financial costs of energy-saving investments, such as purchasing new efficient technology [59]. • The effects of socio-economic factors may differ for day-to-day energy usage as opposed to the one-off adoption of energy efficiency measures. Household income is closely linked with factors such as employment status, education and household size—all of which reflect situational characteristics that may facilitate or constrain energy-related behavior by providing the means by which people can perform everyday actions and take one-off steps to save energy. For example, higher-income households typically own and use more electrical appliances than lower-income households, which may lead to differences in energy use [53,71]. At the same time, a higher total income may also increase a household's capability to invest in one-off energy efficiency measures (e.g., solar panels, insulation, energy-saving devices) that serve to conserve energy. • While most research supports a positive relationship between income and household energy consumption, findings are variable across studies—for example, some studies report weak to insignificant effects [46]. Some researchers have even concluded that middle-income households may be the most likely income group to save energy because low-income consumers are unable to reduce their energy use, while high-income consumers are unwilling to reduce their energy use [52,73].

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Socio-demographic factors	Household size	• Total household energy consumption is positively related to family or household size and composition (*i.e.*, number of persons per residence), such that larger families/households typically consume more energy compared to smaller families/households [6,27,53,69,74]. This may be because larger households generally: (a) possess and/or use more energy-intensive appliances; (b) have more disposable income to spend on energy; and (c) have greater energy demands and requirements (*i.e.*, more cooking, cleaning, washing, heating/cooling, *etc.*). The presence or absence of family members from a household, as well as changes in family composition over time (*i.e.*, new-born baby, older child leaving home, *etc.*) may also influence household energy consumption [8,68]. • However, the relationship between household size and energy use is not perfectly linear and may actually differ when energy consumption is measured per capita as opposed to per household. The sharing of energy services among multiple household members generally leads to lower energy use per capita in larger households, all else being equal [72,75]. That is, the association between household size and energy use is reversed when consumption is measured on a per capita basis. For example, while the highest consuming households tend to be larger families (*i.e.*, couples with children), single-person households actually use the highest amount of energy per capita followed by couple-only, single-parent and two-parent families, respectively [71]. One study has found that two-person households consume around 17% less energy per person for residential and transportation activities than single-person households, with three-person households using more than one-third less energy per person [72]. • The impact of household size may also differ for energy consumption as opposed to conservation. While larger households tend to consume more energy overall, they may also make greater investments in energy efficiency measures. Some research suggests that household size may even have a curvilinear relationship with energy conservation (see Curtain 1976, cited in [50]), with three to four-person households reporting a greater history of past conservation efforts and less expected difficulty in future conservation.
	Dwelling type and size	• Dwelling type (e.g., free-standing houses, townhouses/duplexes, residential units, apartments, *etc.*) appears to directly influence energy consumption because different dwellings vary in important characteristics such as the number of rooms/floors, amount of floor space, degree of insulation, sun and wind exposure, the attributes of energy-using equipment, the number and kind of household appliances, and other critical design features such as wall-cavity insulation, double glazing, energy-efficient heating, ventilation and cooling systems (e.g., [8,68,76]). Some early research has estimated that considering all factors, as much as half of total household energy use depends on the characteristics of existing equipment and the dwelling, with the remainder determined by the features and behavior of occupants [75].

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Socio-demographic factors	Dwelling type and size	• Households residing in larger dwellings, as indexed by number of rooms and floor space (e.g., freestanding homes) typically consume more energy than households residing in smaller dwellings (e.g., units or apartments) [54]. Some research has found that households living in detached houses, townhouses and semi-detached dwellings consumed 74% more electricity than those living in multi-unit dwellings [71]. At the same time, some research has also found that households residing in detached houses are actually more willing to engage in energy conservation activities than those residing in apartment blocks [59]. • Some evidence also indicates that dwelling characteristics can influence the behavior of household members themselves, thereby impacting energy use indirectly. For example, residing in a larger dwelling may signal to consumers that their household uses considerable electricity/gas and that energy-savings and home improvements are therefore more desirable or necessary [47].
	Dwelling age	• The age of a house/dwelling is often expected to be positively associated with household energy consumption, primarily due to the lower energy efficiency standards of older dwellings (e.g., less efficient heating/cooling, poor insulation, energy wasting appliances, *etc.*). • However, some studies have failed to detect statistically significant effects of dwelling age on consumer participation in energy conservation activities such as home energy audits [56], with more recent research also suggesting that newer homes with more energy efficiency appliances do not necessarily reduce a household's overall energy expenditure. In fact, homeowners residing in older dwellings may even be more inclined to adopt energy-efficient measures than those residing in newer dwellings, particularly if older dwellings are in physically or aesthetically in poor condition and require the installation of new appliances or building components [46].
	Home ownership	• Home ownership (e.g., rented *vs.* owner-occupied) appears to indirectly impact energy consumption by way of influencing household investment in energy efficiency measures [10,77,78]. Sardianou [59] summarises key findings from a number of studies (e.g., [43,67,70,77,79,80]) to demonstrate why home ownership is often associated with greater availability of, and access to, energy efficiency measures. Compared to renters, homeowners are more likely to invest in energy efficiency measures because they tend to be wealthier and have greater financial security, hold longer tenure, and receive greater return on energy efficiency investments. Conversely, renters tend to be poorer, more transient, and less willing and/or capable of making home improvements (either due to limited financial resources, lack of control and/or fewer incentives), thereby leading to less financial investment in energy-efficient devices and new technology. • Some early research on the determinants of gasoline and home heating energy conservation found that home ownership was among the most powerful socio-demographic factors distinguishing conservers from non-conservers [1], with subsequent research revealing that it is also one of the most important factors explaining large capital investment in household energy-saving measures [77]. Barr *et al.* [43] have also recently suggested that home ownership may provide consumers with a sense of personal control and belonging that encourages them to focus more conscious attention toward saving energy.

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Socio-demographic factors	Home ownership	• However, other studies have found that homeowners consume more energy than tenants (for a list of studies, see [78]). For example, a recent Australian study found that households who rent their homes actually consumed less energy than homeowners [71].
	Stage of family life cycle	• Many researchers have investigated how household life cycle relates to consumer's economic behavior (e.g., [81,82]). The stage of a family's life cycle—typically defined as a combination of criteria such as family members' age, marital status, and family size/type—appears to be one of the strongest predictors of household energy consumption (for reviews, see [50,55,75]). This is because family life cycle stages are linked with differences in household needs, priorities, and activities—all of which can help explain variability in household energy demands and usage levels. Families in different stages of the life cycle have vastly different attributes in terms of household work (e.g., cleaning, cooking, laundry), childcare, and in-home entertainment (e.g., TV/computer, visits of friends/family, hobbies and recreation, sleeping and resting/relaxation), all of which may influence patterns of energy consumption and conservation. • A reasonable body of research has supported a curvilinear pattern whereby household energy consumption peaks during the child-rearing years. For example, studies have found that families with children typically use more energy than families without children (at either earlier or later stages of the life cycle) or families with children who have left home [50]. According to Lutzenhiser [83], household life cycle (*i.e.*, family age and composition) differences have been reported across a range of criteria including areas such as heating, electricity use, housing needs, overall energy efficiency, building/appliance characteristics, and levels of carbon dioxide pollution. • These differences in household energy consumption across the lifespan may arise from concurrent changes in some of the socio-demographic predictors of energy use, particularly factors such as employment, income, house type/size, and household composition. Because household characteristics may influence the behavior, activities and lifestyles of occupants, any changes in these characteristics over time may subsequently change the energy usage of the household [75].
	Geographical location	• Regional differences in climate, temperature and geography are key determinants of household energy use, with studies in the northern hemisphere finding that households located in more southern regions (*i.e.*, warmer temperatures) tend to consume less energy than households in more northern regions (*i.e.*, colder temperatures) [6,8]. • Rural areas have also been found to have higher levels of energy use than urban areas [8], with these regional differences purportedly arising due to variability in types of houses (e.g., freestanding dwellings *vs.* apartments), life-style characteristics, and house orientation to sunlight and wind. Geographical location may also impact homeowners' attitudes and preferences toward energy conservation—for example, due to the effects of the local governments' actions to encourage and reward energy efficiency measures and behavior [46].

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Socio-demographic factors	Ownership of home technology & technical expertise	• Some researchers have suggested that householders who possess "high-tech" consumer products (e.g., electrical goods, computers, *etc.*) may be attracted toward all types of technical innovation (including energy-saving devices), alongside having more disposable income to invest in such products (*i.e.*, greater financial capacity to purchase new technology); thus, ownership of general (non-energy) home technology may be associated with ownership of more specific energy-saving devices, systems and equipment (e.g., energy efficient appliances, solar power) that assist with energy conservation [10]. • Some research also suggests that the presence of a household member with technical knowledge and skills in home repairs (e.g., home appliance and automotive repairs)—that is, a "handyperson"—is positively related to energy conservation, presumably because such people may have a better understanding of new technology [10] and be more capable of performing installation and ongoing maintenance tasks for energy-saving technology [40,46]. However, "do-it-yourself" consumers may also be less inclined to purchase unfamiliar energy efficiency equipment and appliances if they perceive the installation and maintenance of these items to be complicated, burdensome or requiring expert skills [84]. Indeed, Kollmuss and Agyeman [20] have cited some research showing that very detailed technical knowledge does not inherently facilitate or increase pro-environmental behavior.
Psychological factors	Knowledge & problem awareness	• In the context of energy consumption, energy-related knowledge reflects one's level of knowledge, awareness and understanding of energy costs, energy-saving behavior, and the consequences of such behavior [8]. While greater knowledge, awareness and understanding of environmental issues such as energy conservation tend to be positively associated with pro-environmental behavior (e.g., saving energy) [70,85], greater knowledge and/or awareness does not directly and automatically lead to more pro-environmental behavior per se—that is, there is often a "knowledge-action gap" [14,43,64,65,86]. • Empirical evidence shows that only a small portion of pro-environmental behavior can be directly linked to environmental knowledge and awareness, with Kollmuss and Agyeman [20] citing some research to suggest that at least 80% of the motives for pro-environmental action are other internal and situational factors. While there are exceptions, most studies have failed to consistently detect statistically significant relationships between knowledge and problem awareness and pro-environmental behavior such as energy conservation [14,87,88]. Thus, while greater knowledge and problem awareness is generally positively related to energy savings (and negatively related to energy usage), this relationship is likely to be weak and/or insignificant.

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Psychological factors	Values, attitudes & beliefs	• Values reflect a global, abstract and relatively enduring set of beliefs, ideals and standards that serve as guiding principles in life (e.g., a person's general sense of right *vs.* wrong), whereas attitudes reflect more specific positive or negative evaluations of a particular idea, object, person, situation or activity [89–92]. Many scholars have examined the role of values, attitudes and beliefs in the context of pro-environmental behavior and, more specifically, residential energy usage [6,8,27,93–97]. Some early studies found support for the notion that holding more pro-environmental values, attitudes and beliefs will lead to more pro-environmental behavior [21,93,98]. For example, an early meta-analysis by Hines *et al.* [21] reported a positive relationship between attitudes and pro-environmental behavior, suggesting that people with more positive attitudes were more likely to report engaging in environmentally responsible behavior than those with less positive attitudes. In terms of the specific pro-environmental behavior of sustainable energy use, Becker *et al.* [93] found that householder's attitudes toward thermal comfort and convenience were the most powerful predictors of household energy use; and Seligman *et al.* [98] reported a relatively strong positive association between personal values and residential electricity consumption. • Nevertheless, most empirical evidence indicates that the strength of these associations is often inconsistent, weak and/or insignificant [6,27,53,54,70,99], especially when compared to the effects of socio-demographic factors [7]. It appears that positive values, attitudes and beliefs toward the environment may encourage sustainable behavior (e.g., energy savings, adoption of efficiency measures, *etc.*), but they do not inherently lead to actual reductions in energy use per se [46,53,54,100]. This discrepancy has been referred to as a "value-action gap" and/or "attitude-action gap", and has been observed across many domains of human behavior [26,101–103]. Consistent with this notion, daily life illustrates many situations where people express strong beliefs about the negative consequences of environmental problems (e.g., global warming, climate change, reliance on fossil fuels), or positive evaluations of sustainability and "green" technologies (e.g., renewable energy sources), but fail to translate those beliefs, values and attitudes into practical actions to limit household energy use. • Several scholars have offered useful explanations for how and why environmental attitudes have varying, and typically very small, impacts on pro-environmental behavior (e.g., [8,20,68,102,104]). For example, people typically make choices and behave in ways that minimize costs and maximise benefits to themselves (in terms of time, effort, money, comfort, *etc.*) rather than based on what is "best" for others and the environment [93,94]. Moreover, while attitudes may lead to positive intentions to save energy, various intervening factors (e.g., lack of knowledge about effective actions, social norms, perceived personal responsibility, self-efficacy, anticipated cost-benefit trade-offs, situational and institutional factors, *etc.*) may block this intention from being realised into actual behavior [8,68].

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Psychological factors	Motives, intentions & goals	• Motives are the driving forces or impulses that initiate, guide and maintain goal-directed behavior; that is, the specific reasons why a person acts in a certain way at any given time. Most modern theories define motivation as the process that shapes the intensity, direction and persistence of effort that a person allocates toward achieving a particular goal or desired end state [105–111]. A range of theoretical models have been proposed to explain the various motivations that underpin different types of pro-environmental behavior, including sustainable use of energy [17,44]. Some scholars have drawn on the theory of planned behavior [23] to argue that people make reasoned choices and behave in a way that yields "optimal" outcomes in terms of minimising costs and maximising benefits (in terms of time, effort, money, social approval, *etc.*). Others have focused more heavily on moral and normative concerns by arguing that pro-environmental behavior is positively associated with specific motives related to altruistic, biospheric, prosocial and self-transcendent value orientations (*i.e.*, values beyond one's immediate self-interests), environmental concern, and a sense of moral obligation (see [17,44,63,96,112–114]). • Distinctions have also been made between self-transcendent and self-enhancing goals (for more information, see [89,90]). Some research suggests that whereas self-transcendence goals (e.g., promoting the interests of others and the external world) are positively related to a range of pro-environmental behaviors, the relationship between self-enhancement goals (e.g., focusing on oneself and one's interests) and action is either negative or non-significant. Indeed, Schultz and Zelezny [97] have concluded that people who place a higher value in self-transcendent life goals typically express greater care and concern for environmental issues, as well as exhibiting more pro-environmental behavior. Conversely, those who place higher value in self-enhancing life goals typically have more egotistical concerns about environmental issues and display less pro-environmental behavior. • Intrinsic motives—that is, motivation that stems from personal interest, enjoyment or satisfaction in an activity itself, regardless of external pressures or rewards—have also been associated with pro-environmental behavior [115]. De Young [116] proposed four different intrinsic satisfactions and associated motives that may underpin environmental sustainability: satisfaction from striving for behavioral competence (e.g., enjoyment from solving problems and completing tasks); satisfaction from frugal, thoughtful consumption (e.g., enjoyment from survival based on careful management of finite resources); satisfaction from participating in the community (e.g., enjoyment from being involved in community activities); and satisfaction from luxuries (e.g., enjoyment from convenience and access to new/novel products). Research suggests that individuals who possess intrinsic motivation tend to engage in more durable, sustainable behavior [116–118]. • Researchers have also distinguished between primary and specific motives, with Kollmuss and Agyeman [20] suggesting that the larger primary motives that influence a wide range of behavior (*i.e.*, altruistic and social values around living a pro-environmental lifestyle) are often surpassed or overridden by more immediate, selective motives (*i.e.*, specific motives that influence particular actions and often evolve around one's own needs, such as being comfortable, saving money/time, reducing effort, *etc.*).

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Psychological factors	Motives, intentions & goals	• Goal framing theory [119–121] has been offered as a framework for integrating diverse concepts from the above theoretical perspectives. This theory proposes that at any given moment, human behavior arises from multiple motivations, and goals guide or "frame" how people think, feel and act. Three main motives or "goal frames" have been identified as relevant for predicting pro-environmental behavior: gain goal frames (*i.e.*, a desire to protect and improve one's resources or possessions, such as to save money, protect financial security, *etc.*); normative goal frames (*i.e.*, a desire to act appropriately in line with social and moral standards, that is, to behave in the "right" way); and hedonic goal frames (*i.e.*, a desire to achieve positive self-esteem and improve how one feels at a particular moment, such as to seek pleasure and avoid pain) (for a comprehensive review, see [122]). While motivations are rarely homogeneous and multiple goals can influence behavior, hedonic goal frames are assumed to exert the strongest effects. However, little empirical research exists to support this model, as it has yet to be scientifically tested in the environmental or residential energy usage domains. • In the general psychology literature, many studies also reveal a discrepancy between intentions and behavior, *i.e.*, an "intentions-action gap" [123,124]. For example, a meta-analysis by Sheeran [124] estimated that intentions explain only about 28% of the variance in future behavior, with a more recent mega-analysis finding weak support for the overall impact of changing behavioral intentions on subsequent change in behavior—in fact, it was concluded that a medium-to-large sized change in intention leads to only a small-to-medium change in behavior [125]. Thus, while people driven by certain intentions may be more inclined to engage in energy-saving behavior, simply possessing these intentions does not automatically translate to behavior.
	Personal norms	• It has been suggested that altruistic behavior is activated by personal norms, and acting in manner that is consistent with one's personal norms may lead to positive feelings of pride and self-satisfaction whereas acting in a manner inconsistent with personal norms may lead to negative feelings of guilt and regret. According to the norm activation model [126], pro-social behavior is influenced by moral or personal norms—*i.e.*, feelings of strong moral obligation to perform certain types of pro-social behavior, including pro-environmental actions such as energy conservation (for reviews, see [6,16,27]). For personal norms to be activated, however, a person must first be aware that their behavior has an impact on others and/or the environment (*i.e.*, there must be awareness of consequences), and also feel a sense of personal responsibility for such impacts (*i.e.*, termed "ascription of responsibility"). Consistent with this notion, Abrahamse and Steg [27] have suggested that consumers are likely to feel a stronger obligation to save energy if they believe that energy consumption negatively impacts the environment, and that they are personally responsible. • Evidence from several studies supports the role of moral norms and personal responsibility in explaining individual differences pro-environmental behavior [17,21,77,127,128]. However, the strength of this effect of personal norms is questionable, with some research suggesting that personal norms only guide behavior when they are focal [129]. Thus, while it may be assumed that personal norms will influence household energy usage, simply possessing more positive personal norms is unlikely to directly translate to changes in energy consumption or conservation.

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Psychological factors	Perceived responsibility	• Perceived responsibility reflects the attribution of responsibility (*i.e.*, self-blame, accountability, liability, obligation, *etc.*) for energy conservation to oneself rather than away from oneself to other people, the government, industry bodies, environmental groups, or other external entities [8]. It is often argued that feeling personally responsible for environmental problems (e.g., accepting blame for ecological damage caused by excessive energy use) and for protecting the environment (e.g., feeling obligated to combat climate change by reducing carbon emissions) is positively associated with pro-environmental behavior. A number of researchers have proposed that people who feel personally responsible for environmental problems tend to feel a stronger obligation to help minimise or mitigate them, thereby activating personal norms (e.g., moral obligation to act) and increasing one's willingness to act pro-environmentally (e.g., [6,27]). Denying one's own responsibility, on the other hand, may diffuse blame to an external entity and indicate that there is no need to change one's behavior or lifestyle [8]. Accepting personal responsibility for sustainable energy use is therefore hypothesized to be a positive predictor of energy-saving behavior [43,94,95,130]. However, the strength of this relationship may be weak due to the same processes implicated in the aforementioned "value-action gap" [26,101–103]. • In terms of empirical evidence, Hummel *et al.* [131] (cited in Van Raaij & Verhallen, 1983a) found that perceived self-blame of energy consumers was related to a greater willingness to save energy, whereas diffusing blame for the energy crisis was related to less willingness to conserve. In subsequent research, Hines *et al.* [21] proposed that personal responsibility may be expressed in various ways, for example in terms of the environment as a whole (e.g., personal responsibility to protect the environment, social responsibility to the community) and/or in terms of only one facet of the environment (e.g., personal responsibility felt for reducing energy). Based on a meta-analysis, these authors concluded that those who feel some degree of personal responsibility toward the environment are more likely to display responsible environmental behavior than those who do not feel personally responsible. Given that other research from the general psychological literature shows there is often a discrepancy between intentions and action, however, the strength of the relationship between perceived responsibility and the specific pro-environmental behavior of energy conservation may not always be consistent or reliable.
	Locus of control, self-efficacy, and perceived behavioral control	• Locus of control reflects a person's perception of whether they have the capability to enact change and/or control events that impact them. Individuals with a strong internal locus of control believe that they can exercise personal control over their own decisions, life circumstances and outcomes (*i.e.*, belief that events arise primarily from internal factors, such as one's own motivation and actions), whereas those with a strong external locus of control believe that decisions, life circumstances and outcomes are controlled by environmental factors outside their influence (*i.e.*, belief that events arise primarily from external factors, such as other people, the government, socio-economic influences, *etc.*). This factor is similar to perceived instrumentality, self-efficacy, perceived behavioral control [27,123,124].

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Psychological factors	Locus of control, self-efficacy, and perceived behavioral control	• A large body of literature suggests that locus of control is associated with a person's values, attitudes and intentions to engage in pro-environmental behavior such as energy conservation (for a recent empirical analysis of the various linkages between perceived behavioural control and constructs such as attitudes, social and moral norms, feelings of guilt, and intentions to engage in pro-environmental behaviour, see [16]); however, the extent to which this then translates to action is highly questionable, with behavioral effects sometimes very weak and/or insignificant. • Compared to individuals with a strong internal locus of control, those with an external locus of control may be less likely to behave in a pro-environmental way because they perceive that such behavior is inefficacious and "doesn't make a difference" [20]. In the context of energy consumption, for example, householders may be more likely to conserve energy if they believe that reducing consumption will be effective in yielding valued outcomes, such as reducing costs and/or increasing benefits (*i.e.*, protecting the environment, saving money, *etc.*); but less likely to conserve energy if they believe that their personal contributions are marginal and ineffective. Consistent with this notion, an early meta-analysis by Hines *et al.* [21] revealed a strong positive association between locus of control and pro-environmental behavior, such that individuals with an internal locus of control were more likely to report engaging in environmentally responsible behavior than those with a more external locus of control. However, subsequent empirical studies have revealed mixed findings. Sheeran *et al.* [123,124] have reported that individuals with equivalent perceived behavioral control may oftentimes differ in their subsequent behavior.
	Perceived cost: benefit ratio	• People are often motivated by self-interest and try to select alternatives that yield the highest benefit for the lowest cost—where "benefits" and "costs" may include scarce or valued resources such as time, effort, money, social status/acceptance, convenience, comfort, and so forth. Both economic and behavioral cost-benefit tradeoffs may influence pro-environmental behavior such as household energy consumption and conservation (for further details, see [8,122]). For example, Midden and Ritsema [130] explored several categories of perceived advantages and disadvantages of energy conservation that may be important: personal disadvantages (e.g., beliefs regarding loss of comfort, coldness, unhealthiness, behavioral constraints, *etc.* imposed by an energy-saving lifestyle), societal advantages (e.g., beliefs regarding less environmental pollution, more energy for future generations, world energy supplies, *etc.*) and personal responsibility (e.g., beliefs regarding a sense of duty/responsibility).

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Psychological factors	Perceived cost: benefit ratio	• From an economic perspective, financial costs (or benefits) include the monetary expenses (or potential savings) that households incur from consuming and/or conserving energy [43,76,95]. The high financial costs of adopting one-off efficiency measures may decrease the likelihood of engaging in conservation initiatives, with long-term monetary payoffs also playing an important role. While people may be keen to purchase new appliances and undertake house improvements to optimise energy efficiency (e.g., installing solar panels, insulation, low-energy appliances), the immediate financial costs incurred by such activities may constrain them from doing so, or otherwise act as a disincentive (particularly if there are no immediate benefits). At the same time, energy usage costs may impact homeowners' choice of efficiency measures in the opposite direction: that is, consumers who perceive the costs of consumption or inefficiency to be high might be more motivated to take extra steps to reduce consumption (and thus utility bill expenses), particularly if they believe that non-investment in energy-saving measures is unlikely to reduce costs, or potentially make existing costs even worse [46,77]. Indeed, a recent study by Nair *et al.* [46] found that individuals who perceived their household energy costs to be high were more likely to adopt investment measures compared to those who perceived their costs to be low, which suggest that increases in energy prices may actually encourage consumers to actively search for, and invest in measures that will yield energy savings. • The concept of time inconsistency—that is, the tendency for people to be very short-sighted when some costs or benefits are immediate, but more farsighted when all costs and benefits are in the future—is also relevant for understanding the potential impact of cost: benefit appraisals. In daily life, there are countless situations where people procrastinate, postpone decisions, or delay actions because they are viewed as costly in the short-term, despite offering long-term benefits. In the context of energy usage, consumers may be reluctant to outlay the high monetary costs of investing in one-off efficiency measures today even if it leads to substantial monetary savings on energy bills (and environmental benefits, such as reduced carbon emissions) in a few years. Considerable evidence supports this tendency for people to value immediate rewards (and dislike immediate costs) far more than they value future rewards (and dislike future costs) [132–134].
	Need for personal comfort	• Personal comfort, particularly the perceived loss of comfort that any energy-saving measure might impose, may have a sizeable impact on household energy consumption [43,76,94,95,130]. Any decrease in personal comfort, or perceived threat to lifestyle quality, may reduce the likelihood of engaging in conservation behavior. Empirical research has found that consumers' perceptions of comfort and health are related to energy consumption in both summer and winter seasons [55,93,98]. Some early research found that the combined effect of comfort and health was a significant predictor, accounting for 30% of the variability in a household's actual electric consumption. Results revealed that the more a household perceived energy-saving behavior as leading to discomfort and ill-health, the more energy that particular household consumed [98].

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
	Need for personal comfort	• More recently, Barr *et al.* [43] examined the level of comfort that people with different characteristics are willing to accept in relation to energy-saving behavior. Results revealed that while over 60% of "committed environmentalists" were willing to sacrifice some comfort in order to save energy, less than 25% of "non-environmentalists" were willing to do so. Furthermore, while less than 20% of "committed environmentalists" rated "feeling comfortable around the home" to be an important issue to them, this factor was considered important for almost 60% of "non-environmentalists".
Psychological factors	Normative social influence	• It is well established that human beings make social comparisons, follow the behavior of other people, conform to social norms—*i.e.*, the explicit and/or implicit rules, guidelines or behavioral expectations within a group or society that guide what is considered normal and/or desirable [135–139]. Two distinct types of social influence can motivate human action to conform: injunctive norms, which raise a person's awareness of the attitudes and/or behavior that are typically approved or disapproved by a social group (*i.e.*, what people should think or do); and descriptive norms, which raise a person's awareness of the attitudes and/or behavior that are typically adopted, supported or performed by a social group (*i.e.*, what people actually think or do). Various factors can strengthen or weaken normative influence (e.g., group cohesion, group size, social support), but the final result—conformity—tends to be consistent and pervasive [140]. • Considerable research has identified group membership and normative social influences as having significant impacts on energy consumption and conservation [10,12,130]. In early work, Costanzo *et al.* [10] proposed a social-psychological model of energy conservation that highlighted the importance of social influence, diffusion and reference groups (*i.e.*, friends, family, other social networks) in promoting and maintaining energy conservation. This model proposes that information transmitted via social diffusion is more likely to influence behavior because it tends to be more easily perceived, favourably evaluated, and better understood and remembered than information transmitted via traditional means of education, marketing and advertising. As such, interpersonal sources of information may be more influential than media appeals in eliciting and sustaining reductions in energy use. Other researchers have made similar arguments, with Stern ([11], p. 1229) suggesting that the personal opinions and actions of one's friends may have a more powerful influence over household energy choices than expert advice, even if the latter is better informed.

Table 1. *Cont.*

Category	Predictor	Impact on household energy consumption and conservation behavior
Psychological factors	Normative social influence	• Extensive evidence from the behavioral economics and behavior change literatures supports the impact of normative information on residential energy usage (for an overview, see [141]). Many studies have examined the behavioral effects of providing consumers with information about descriptive norms—*i.e.*, personalised messages or communication containing details of one's energy consumption relative to a neighbourhood norm—with extensive evidence supporting the behavioral impact of this comparative information (e.g., [141–146]). For example, Nolan *et al.* [146] found that delivering a descriptive normative message (*i.e.*, information about the conservation behavior of one's neighbours) motivated consumers to save more energy than a control message or any other messages that included appeals traditionally accorded motivational power (e.g., protecting environment, saving money, being socially responsible). Ayres *et al.* [144] found similar support for the effectiveness of descriptive norms, with two experiments revealing that normative social information can lead to energy savings of between 1.2% and 2.1%. More recently, Allcott [141] found that providing descriptive normative information led to an average residential energy saving of 2.0%. However, these effects were heterogeneous, with above-average consumers saving far more energy than below-average users.

- Ownership of non-energy technology (e.g., "high-tech" products like computers and gadgets) is often related to greater use of energy-saving devices and systems (e.g., energy efficient appliances). The presence of "handy" household members with technical knowledge and skills in home repairs (e.g., home appliance and automotive repairs) has also been linked with energy conservation. However, very detailed technical knowledge does not consistently promote pro-environmental behavior.
- Regional differences in climate, temperature and geography are closely related to energy use, with households located in colder zones typically consuming more energy than households in warmer zones. Households in rural regions also tend to have higher levels of energy use than those in urban areas, other things being equal.

4.2. Psychological Factors Related to Household Energy Consumption

While socio-demographic factors clearly play an important, albeit complex role in household energy consumption and conservation, a range of person-specific psychological factors may also have powerful effects (e.g., [8,9,11,27,104]). As shown in the bottom portion of Table 1, some of the psychological factors most commonly associated with household energy usage include: knowledge and problem awareness (both of environmental and energy issues); beliefs, values and attitudes; motives, intentions and goals; subjective appraisals and perceptions (e.g., cost-benefit trade-offs; perceived behavioral control); personality tendencies (e.g., self-efficacy, locus of control); and personal and social norms. Our review of the literature shows considerable attention being paid to the influence of values, attitudes and beliefs, as well as motivational constructs such as goals and intentions, but relative less emphasis on investigating variables such as locus of control and self-efficacy. This variation in the attention paid to different psychological constructs is reflected in Table 1, and adds another dimension to our understanding of the extant literature and what we can rightly make of the evidence currently available.

Before reviewing the key findings regarding these psychological factors, we point out that over the years there has been some variation and even marked shifts in the definition of some of these constructs, particularly beliefs, values, attitudes and motives (for more detailed reviews, see [89–91,117,147–151]). There is considerable overlap among the latter factors, in particular, and ongoing debate over their precise definitions and degree of relatedness. Some scholars use the terms somewhat interchangeably while others argue that they represent conceptually and operationally distinct constructs. For example, some researchers have examined the value basis of environmental beliefs and behavior by distinguishing between egoistic, altruistic and biospheric values, value orientations and/or attitudes (e.g., [97,112,114,152]), whereas others have explored these same categories—egoistic, altruistic and biospheric—as applied to motives (e.g., [96,114,153,154]). We will avoid unnecessarily complicating the current review by simply adopting the most common conceptualizations and usages of each construct.

As shown in Table 1, some of the general findings to emerge from research exploring the specific psychological and motivational variables that influence patterns of household energy consumption and conservation include the following:

- Knowledge, awareness and understanding of environmental issues (e.g., energy-related problems) does not always lead directly and consistently to pro-environmental behavior such as

energy conservation. Rather, there may often be a "knowledge-action gap" [65], such that increasing knowledge and awareness does not routinely translate into congruent behavioral change, perhaps due to the influence of various moderating factors that may constrain or facilitate energy-related behavior.

- Likewise, pro-environmental values, beliefs and attitudes do not reliably translate to congruent changes in energy consumption or conservation, with the relationship between values and behavior ultimately contingent upon various moderating factors, such as knowledge, problem awareness, household technology, socio-demographic constraints, and the like. In the end, there may often be a marked "value-action gap" and/or "attitude-action gap" [26,102,103].
- Likewise, we might reasonably expect that people who are driven by certain goals (e.g., self-transcendence *versus* self-enhancing goals; hedonic *versus* gain frames) and motives (e.g., pro-social, altruistic) will be inclined toward energy-saving behavior. But again, the relationship between "good intentions" and actual behavior depends ultimately on moderating factors. Again, we are often left with a marked "intention-action gap" [123,124], with possession of environmentally friendly goals and motives failing to translate—reliably and consistently—into environmentally friendly behavior, such as energy conservation.
- Personal norms (e.g., feeling a strong moral obligation to act in a pro-social, altruistic manner) tend to encourage pro-environmental behavior such as energy conservation. But this relationship may be contingent on awareness of the consequences of one's behavior and ascription of felt responsibility for these behavioral consequences.
- Perceived responsibility for environmental issues and problems tends to be positively associated with pro-environmental behavior and sustainable consumption, presumably because people who feel personally responsible for a particular problem also tend to feel a stronger obligation to help minimize and mitigate it, thereby activating personal norms (e.g., moral obligation to act). However, the precise strength of these associations depends on a range of other mediating and moderating factors.
- Perceived behavioral control (and the associated construct of self-efficacy) tends to be positively associated with pro-environmental behavior such as energy conservation, such that individuals with an internal locus of control are more likely to engage in pro-environmental behavior than those with a more external locus of control. Similar to personal norms and perceived responsibility, however, the strength of this association depends on a range of other mediators and moderators.
- Both economic and behavioral cost-benefit tradeoffs may influence energy consumption and conservation, with people tending (other things being equal) to select courses of action that yield the highest benefit for the lowest cost (in terms of time, effort, money, status/prestige, social approval, comfort, convenience, *etc.*). However, research in behavioral economics shows that people are also frequently prone to a range of cognitive biases, heuristics and other anomalies in their decision-making and behavioral choices—including around environmental protection, renewable and sustainable technologies, and energy consumption—which cause them to act in seemingly "irrational" ways that diverge markedly from traditional economic models of behavior [104,155–158].
- Personal comfort, particularly the perceived loss of comfort that energy-saving measures may entail, can have a powerful influence on household energy usage. Any decrease in personal comfort, or reduction in lifestyle quality, may reduce the likelihood of householders engaging in energy conservation behavior.

- Group membership and normative social influence (e.g., the perceived energy-related practices of one's peers or neighbors, and social pressure from family/friends to save energy) can significantly influence household energy use. Much research indicates that people tend to behave in ways similar to those around them (*i.e.*, people desire normalcy and often exhibit conformity). This is largely due to the effects of social norms—those explicit and implicit "rules" or expectations that guide what is deemed normal, common and/or desirable behavior in society. In terms of pro-environmental actions, injunctive norms (*i.e.*, perceptions of what attitudes and behavior are approved/desired by a social group with whom one associates or identifies) and descriptive norms (*i.e.*, perceptions of what attitudes and behavior are normal/common among this social group) can both exercise great influence over behavior.

4.3. Summary of Key Findings and Conclusions

Our comprehensive literature review has revealed that household energy consumption and conservation are associated with a number of socio-demographic and psychological variables, but that these associations are not always substantial, straightforward or consistent, making it difficult (and certainly more difficult than is typically assumed) to draw definitive conclusions across studies. Indeed, it is clear that most of the factors we have reviewed actually interact with other variables, often in rather complex ways, and that their impact is heavily contingent upon those "moderating" factors. It is not simply a matter of household energy use being shaped—in a direct and linear fashion—by just a few principal individual-level factors. Rather, there are a multitude of variables (predictors, mediators and moderators) that together influence the nature, intensity and duration of behavior around energy consumption and conservation [10,14,19,20]. This complexity and inconsistency pose some challenges for drawing firm conclusions about specific effects (e.g., the size and direction of a particular variable's impact on household energy use), and especially for generalizing findings more broadly. Accordingly, we strongly recommend that researchers and practitioners exercise due caution when drawing inferences regarding the effects of individual variables as reported herein, without taking careful account of the complex interplay among the various factors.

In terms of socio-demographic predictors, our review suggests that several factors (e.g., household income, dwelling type/size, home ownership, family size/composition) are strongly associated with household energy usage, but in some cases the effects are mixed. For example, while a few studies suggest curvilinear effects on energy consumption for certain socio-demographic factors (e.g., age, income, stage of family life cycle), this non-linear pattern does not always hold up in other studies. To illustrate, some research has suggested that middle-income households are actually most likely to save energy, with low-income households (already, by necessity, consuming little energy) simply unable, and high-income households unwilling, to reduce usage [52,73]. However, most research has observed a simple linear association [6,7,27,53,54,69–72]. Moreover, the relationship (whether curvilinear or otherwise) between income and energy use is expected also to be influenced by the greater capacity of higher income householders to invest in energy efficiency technologies and measures. If we take proper account of these nuances, it would be misleading simply to claim that higher income leads to greater household energy consumption. This pattern of results for income is just one example of the many complexities we identified in the literature. It is clear that the extent to which socio-demographic

variables influence household energy usage depends on complex and dynamic interactions among different factors, sometimes simultaneous, and other times unfolding over time.

In terms of psychological predictors of energy usage, our review identified several factors that seem to play an important role, with normative social influence being especially powerful. But the results for many of the other psychological factors we reviewed were again far from consistent and conclusive across studies. For example, we identified a wealth of research investigating the impact on household energy usage of variables such as knowledge and awareness; beliefs, values and attitudes; goals, motives and intentions; and personal and social norms. Yet the available evidence indicates that environmentally friendly knowledge and values do not reliably predict environmentally friendly actions—there is often a sizable discrepancy between "good intentions" and actual behavior. Furthermore, the empirical evidence on balance suggests that the effects of many psychological factors (like values, attitudes and beliefs) on subsequent energy behavior tend to be small and/or weak [6,27,53,54,70,99]—often failing to attain statistical significance—especially compared to the effects of socio-demographic factors [7]. For instance, Poortinga *et al.* [7] found that while attitudinal variables explained a mere 2% of variation in home energy use, the variance explained increased to 15% after taking into account several socio-demographic variables. The relatively poor correspondence between psychological factors and actual energy use suggests that future energy-saving initiatives must direct considerable additional efforts toward helping people act in accordance with their underlying values, beliefs and attitudes, and ultimately, to translate their good intentions into tangible changes in energy consumption and conservation.

In summary then, while some general trends have emerged from the literature, it is clear that predicting and explaining household energy consumption and conservation is considerably more complex than often assumed. This complexity has previously been remarked not only for the specific domain of energy usage, but also for the broader domain of pro-environmental behavior (see Hines *et al.*'s [21] early meta-analysis). Similar to many other forms of environmentally significant behavior, household energy usage is a complex phenomenon, which is worked upon—directly and indirectly—by a great variety of factors. In the end, a multiplicity of forces interact to influence the nature, intensity and duration of household energy conservation [10,14,19,20]. If the researcher or practitioner seeks specific guidance—lessons applicable to a particular type of householder, context, or point in time—then we must caution them always to take care to undertake their own focused study, one that can reveal the complex interplay of forces bearing upon their specific problem and population of interest.

Nevertheless, the general trends and broad conclusions we have managed to draw out remain illuminating to the extent that they highlight how different types of consumers can have markedly different socio-demographic, psychological and behavioral profiles. When designing and implementing energy-saving interventions, it would be useful for policymakers to identify what unique household profiles exist in their target population. Different types of consumers and households are bound to have vastly different characteristics, needs, and living arrangements. The environments in which people live, and their ability and willingness to control energy use by taking certain actions, will vary widely. To take a simple example, it is likely that conventional energy-saving tips aimed at homeowners living in free-standing dwellings are far less applicable and persuasive for those living in master-metered apartments or subsidized accommodation [159]. It is also likely that strategies promoting financial investment in one-off efficiency measures (e.g., home improvements, such as installing energy-saving

retrofits or purchasing new energy efficient technology) are better targeted at high-income households that can afford to outlay money for such measures. Low-income households may benefit more from inexpensive behavioral strategies that help them to recognize and modify certain key energy-wasting practices [51]. By understanding the unique profiles of customers, policymakers will be better placed to identify and target opportunities for effective behavior change, along with the messages and motivational strategies most likely to sustain that change in the specific population of interest.

5. Practical Implications and Directions for Future Research

The key findings and conclusions presented in this paper have important implications for future research and practice. Greater knowledge and understanding of precisely what drives energy consumption and conservation in households, alongside when, where, how, why and for whom this occurs, can make a valuable contribution toward the cost-effective design and delivery of consumer-focused behavioral interventions to promote energy efficiency. Developing innovative, evidence-based solutions to reduce energy consumption—particularly solutions that are cost-effective, mass-scalable and generalizable to broad sections of the community—is currently a major priority at local, national and international levels. Any viable long-term solution to curtailing rising residential energy usage relies on addressing the major determinants of consumer behavior. This naturally includes consideration of the various socio-demographic and psychological characteristics of individuals themselves, alongside immediate contextual factors (which are still bound to an individual's psychology via the automatic perception of, or deliberate appraisal of, their environment) that influence behavior. While promoting societal acceptance and uptake of new energy efficient technology and low-emission "green" energy sources can go some way toward solving the world's energy-related problems, longer-term behavior change in the day-to-day usage of such technology and the enactment of other everyday energy-consuming practices is also at the crux of achieving significant reductions in residential energy usage.

To date, a range of strategies have been developed to encourage pro-environmental behavior among consumers, including behavior change interventions to reduce residential energy consumption and/or improve efficiency [44,160–164]. Such interventions have typically targeted many of the individual-level factors (or the individual's immediate environment) reviewed in this paper. Interventions have ranged from so-called "antecedent strategies" aimed at changing the factors that precede consumer behavior—such as basic information provision and education; goal-setting and commitment strategies; and the use of social/group norms, peer influence and social modeling—through to more "consequence" strategies aimed at changing the outcomes of such behavior—such as self-monitoring; delivering feedback (on one's behavior or performance); and the use of rewards (intrinsic and extrinsic) and other incentives [14,165]. While the literature suggests that all of these strategies have the potential to motivate pro-environmental behavior, the effects have been far from robust and consistent across studies—certain strategies have been found to be effective in some contexts, for some people, and for some types of behavior, but not others (for an overview, see [166]).

Interestingly, the efficacy of different behavioral interventions appears to be highly domain-specific—that is, contingent on the specific type of pro-environmental behavior in question. In an extensive meta-analysis, Osbaldiston and Schott [161] found statistically significant variation in the effect sizes of treatments for different types of pro-environmental behavior (e.g., public recycling,

public energy conservation, water conservation, gasoline conservation, curbside recycling, central location recycling, home energy conservation, home energy adoption, and other behaviors), such that no single treatment or intervention was highly effective across all of the behaviors. Rather, there was considerable variability across the different types of behavior in the extent to which certain interventions were (in)effective relative to others. In terms of home energy conservation, treatments that included social modeling, commitment and rewards were found to be most effective, with goal-setting, cognitive dissonance and feedback showing modest effects. In contrast, treatments involving instructions, justifications and prompts to save energy had comparatively weaker, if any, effects. While more empirical research is clearly needed, these results suggest that there may be value in examining the underlying socio-demographic and psychological correlates of specific energy-related practices when designing interventions, rather than simply focusing on the more general domains of consumption and conservation. It may well be that specific energy-related practices (*i.e.*, showering, laundering, space heating/cooling) have different underlying predictors, such that marked variation exists in the responsiveness of these specific practices to different treatments. In addition, practitioners and policymakers are strongly advised to undertake a comprehensive analysis of their specific target population of interest before designing and implementing their own interventions in the field. In particular, it is important to take into account the socio-demographic and psychological profiles of the target population, as well as the relevant contextual factors and experiences (social, cultural economic, political, environmental) that may influence this population.

In parallel, the overall success of any tailored intervention to motivate and sustain positive change in consumer behavior can be enhanced by gaining greater knowledge of the specific antecedents (*i.e.*, predictors) of such behavior, as well as by better understanding the underlying explanatory variables (*i.e.*, mediators) and factors that may influence the nature, intensity, frequency and duration of that behavior (*i.e.*, moderators). This review has highlighted that there are various socio-demographic and psychological factors that may predict (albeit to differing degrees) energy consumption and conservation. In terms of changing behavior, therefore, practitioners and policymakers would be well-placed to focus greatest attention toward those predictors that are most strongly and consistently related to energy usage, and most malleable and responsive to external influences. For example, compared to traditional information-intensive interventions such as educational campaigns that aim to increase knowledge and modify deep-seated beliefs and values, lower-cost strategies that capitalize on behavioral economics principles (e.g., message framing, choice architecture and incentives) to target psychological factors such as cost-benefit appraisals and social norms may prove more impactful [104]. At the same time, it is also imperative to consider the socio-demographic and psychological profiles of individual consumers and households, to ensure behavioral strategies are appropriately tailored and customized to the target population of interest. Finally, both before and after implementing any behavior change intervention, it is critically important for policymakers to consider cost-effectiveness and return-on-investment—not only compared to business-as-usual (*i.e.*, compared to not implementing the intervention at all), but equally importantly, compared to other strategies that may achieve similar results but in a far more/less expensive and mass-scalable manner.

Moving forward, there is still vast scope to extend our understanding of unique customer and household profiles by drawing on the key findings from our review. In particular, the literature could be advanced by developing and testing an evidence-based framework for consumer segmentation that

incorporates many of the socio-demographic and psychological factors variables discussed in this paper, and that successfully and usefully distinguishes consumers with different energy-consuming patterns of use. A systematic and consistent framework—validated by empirical evidence—would enable researchers, policymakers and industry experts to better predict how different types of energy consumers are likely to behave in different contexts and at different points in time. Such insight would also enable the design and delivery of tailored intervention efforts that might ultimately be more cost-effective than alternative mass-market solutions.

6. Conclusions

In conclusion, this article has demonstrated that there are a number of individual-level predictors of household energy consumption and conservation. Based on a review of theory and evidence from the social and behavioral sciences, we have identified two broad categories of variables that are commonly proposed as explaining variability in energy usage: socio-demographic and psychological factors. While the influence of specific predictors within each of these categories has not always been consistent or conclusive across studies, we have sought to bring some clarity to the literature by summarizing some of the more robust, generalizable findings that have emerged to date. In doing so, we have highlighted the importance of taking multiple factors into account when aiming to design and deliver strategies that reduce consumption and increase conservation. By shedding more light on precisely what drives consumer behavior, this paper provides practitioners and policymakers with useful insights for developing cost-effective solutions that target and exploit these individual-level predictors of household energy consumption and conservation. We hope that the key findings from our review help to advance the design and delivery of behavior change interventions that will ultimately assist individual consumers, households and entire communities achieve greater sustainability in the use of energy, both now and in the future.

Author Contributions

All three authors were involved in conceiving the aims, objectives, scope and structure of the review. Elisha Frederiks was responsible for conducting the literature review and writing the manuscript. Karen Stenner and Elizabeth Hobman both reviewed and edited the manuscript drafts. All authors have therefore been involved in the preparation and have approved the submitted manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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