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What Drives Sustainable Energy Use? A Case Study from Jordanian Households

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Abstract

This study examines the factors influencing energy-saving behaviors in Jordanian households by expanding the Theory of Planned Behavior (TPB). Incorporating additional variables, such as energy poverty, eco-literacy, and environmental concern, this study utilizes survey data collected through online tools. The findings reveal that environmental concern and eco-literacy significantly influence attitudes, perceived behavioral control, and subjective norms, with attitudes emerging as the dominant predictor of environmentally sustainable intentions. These intentions, in turn, positively influence actual sustainable behaviors. Energy poverty directly affects both intentions and behaviors, moderating key relationships within the model, notably diminishing the influence of attitudes on intentions and the translation of intentions into behavior. The results validate the applicability of TPB to sustainable energy practices and demonstrate the importance of addressing economic barriers. Overall, the findings suggest that fostering environmental concern and eco-literacy is necessary but insufficient without interventions that mitigate financial constraints associated with energy poverty.

Keywords: energy conservation; energy poverty; theory of planned behavior; pro-environmental behavior; climate change; Jordan; MENA region

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1. Introduction

Climate change mitigation is driven by global efforts to reduce greenhouse gas emissions and promote equitable access to affordable, clean energy [1]. Climate change mitigation strategies emphasize the role of energy efficiency and sufficiency as key components [2]. Individuals can mitigate the impacts of climate change by adopting low-carbon lifestyles in their personal lives to reduce their carbon footprint (e.g., energy conservation), and engaging in collective environmental actions in the public sphere (i.e., environmental protests) [3–5]. Nowadays, individuals are increasingly aware of the significant environmental impacts of their energy use [6]. In recent years, reducing personal energy use has become ever more recognized as an individual's responsibility [7]. However, the active involvement of citizens, municipalities, and community organizations in promoting energy efficiency has the potential to bring about significant changes in consumer behavior [8]. Energy conservation not only provides substantial rewards for individuals and organizations, but it can also be achieved through simple, inexpensive behavioral adaptations.

Despite arguments about the potential costs of adoption, even standard practices—such as switching off unnecessary lights—can cumulatively reduce energy use, decrease emissions, and contribute to broader environmental objectives [9]. Additionally, households can save energy by receiving feedback, setting goals, and receiving energy-saving tips [10].

In the second week of August 2025, Jordan experienced a severe heatwave, with temperatures rising above 44 degrees in some areas [11,12]. During this period, the National Electric Power Company (NEPCO) reported a record maximum electric load of 4460 out of 4800 megawatts on August 9th, which then increased to 4800 megawatts on August 13th, putting more pressure on the power grid and electricity demand [13,14]. Additionally, the Electricity Distribution Company (EDCO), responsible for electricity distribution in Jordan's Southern Regions, announced that there would be no power outages due to unpaid bills during the heatwave [15]. All these events led NEPCO to reach out to people via social media and ask them to help save electricity by turning off air conditioners for a while and switching off unnecessary devices and lights to prevent blackouts caused by the grid's strain [16].

Although pro-environmental behaviors have been extensively examined within high-income contexts through frameworks such as the Theory of Planned Behavior (TPB), evidence specific to Jordan remains limited. Recent qualitative research conducted in northern Jordan emphasizes local motivations and obstacles to household electricity conservation [17]. Studies utilizing the TPB—especially in the domain of renewable energy adoption—demonstrate that energy literacy and attitudes significantly influence intentions, whereas the actual condition of energy poverty may moderate these effects [18,19]. Furthermore, energy poverty impacts more than half of Jordanian households, particularly in peripheral and lower-income regions, exhibiting a spatial dimension associated with climate vulnerability and access to cooling during extreme heat events [20,21]. Moreover, residential buildings in Jordan constitute a disproportionately high share of overall energy consumption and present a considerable opportunity for efficiency improvements through behavioral modifications and technical interventions [22]. Collectively, these findings suggest that Jordan is a context where socioeconomic, educational, infrastructural, and climatic factors intersect. This underscores the necessity to augment the TPB with additional constructs, such as eco-literacy, environmental concern, and energy poverty, to attain a more comprehensive understanding of energy-saving behaviors.

All these circumstances demonstrate that saving energy is not only an economic issue that benefits households, but also a climate-related issue that can mitigate climate impacts while reducing energy bills. In this context, understanding human behavior in Jordan is crucial for developing more effective policies and regulations. This study advances the literature on energy-saving behavior in several ways. First, it uses an expanded version of TPB to examine energy-saving behavior in Jordanian households, including three additional factors: energy poverty, eco-literacy, and environmental concern. Second, although many studies have applied TPB to analyze pro-environmental behavior, this research incorporates the concept of energy poverty, which, to our knowledge, has not been used to understand how energy-poor individuals manage energy-saving in their daily lives. Third, despite extensive research on the topic, there is limited understanding of energy-saving behaviors and practices in the Middle East and North Africa (MENA). Therefore, we hope this contribution will spark a new dialogue and encourage further research on this subject in the region.

This paper proceeds with a brief literature review in Section 2. Section 3 introduces the materials and methods, followed by the results in Section 4. Section 5 presents the discussion, and Section 6 briefly outlines the study's conclusions and limitations.

2. Literature Review and Theoretical Framework

The Theory of Planned Behavior is frequently utilized in studies to investigate the correlation between individuals' behavioral intentions and their ensuing actual behavior [23,24]. Based on [25] work, attitude toward behavior, subjective norms, and perceived behavioral control affect behavioral intention, which in turn determines actual behavior. This study aims to extend the theory of planned behavior by including three additional factors to explore students' energy-saving behavior.

Theory of Planned Behavior (TPB) identifies intention as the preceding antecedent to behavior that is controlled by behavioral attitude, subjective norms, and perceived behavioral control (PBC) [25]. TPB has been successfully applied to pro-environmental behavior, such as electricity saving and effective energy use, and generally exhibits positive correlations between the three determinants and intentions, as well as, to some extent, stated behavior [26–28]. TPB has already been shown to be effective in explaining the adoption intentions of distributed renewables in Jordan, with attitude and PBC appearing as significant predictors [19,29]. Based on this evidence, TPB is applied as the primary model due to three context-specific factors in Jordanian households: eco-literacy, environmental concerns, and energy poverty.

2.1. Environmental Concern

Environmental concern reflects awareness of environmental problems and a sense of responsibility to address them; it operates, in part, through personal moral norms and attitudinal assessments [30]. The level of environmental concern has a significant influence on people's behavior in specific environmentally related areas, such as recycling, energy conservation, purchasing eco-friendly products, or choosing environmentally friendly transportation modes [31]. It is argued that environmental concern has no relationship with educational level [32]. All demographic groups in Jordan exhibit moderate to high levels of environmental concern, according to survey-based studies; however, due to barriers related to cost and credibility, there remain gaps between concern and action [33,34]. Bridging concern with reliable, low-friction action can thus convert values into intention. Therefore, we hypothesize that:

H1. *Environmental concerns have a significant influence on attitudes (H1.1), perceived behavioral control (H1.2), and subjective norms (H1.3) toward energy-saving behavior.*

2.2. Eco Literacy

Eco literacy is rooted in the broader humanities, emphasizing the creation of sustainable human communities [35] and is different from other literacies, such as environmental literacy, it focuses on sustainability as a core goal, ethical and spiritual engagement with the environment, and actions within ecosystems and communities [35]. Knowledge alone rarely guarantees behavior change, but it consistently influences attitudes and perceived control, the immediate TPB drivers of intention [36,37]. Household studies indicate that knowledge of efficient technology and understanding of bills are associated with conservation intentions and the adoption of efficient appliances [38]. In Jordan, consumer awareness was among the strongest predictors of intention to utilize solar systems [18]. Therefore, we hypothesize that:

H2. *Eco-Literacy has a significant influence on attitudes (H2.1), perceived behavioral control (H2.2), and subjective norms (H2.3) toward energy-saving behavior.*

2.3. Attitude

Attitude refers to an overall opinion about saving electricity at home. TPB assumes that positive attitudes support intention [25]. Multi-country surveys and experiments consistently correlate positive conservation attitudes with stronger intentions to consume less or invest in efficiency [39]; however, the translation of these attitudes into observed behavior can be undermined by situational barriers [26,27,40]. In Jordan, attitudes towards residential renewables and saving are generally favorable and are materially linked to adoption intentions [17,19]. Such findings suggest that locally credible demonstrations of comfort, reliability, and bill savings have the potential to enhance pro-saving attitudes. Therefore, we hypothesize that:

H3. *People's attitude has a significant influence on energy-saving intentions.*

2.4. Perceived Behavioral Control

PBC assesses the perceived ease and difficulty of energy-saving behaviors in terms of available resources, available time, and financial constraints. Stronger PBC tends to reinforce intention and directly impact behavior when perceived control improves with actual control [25]. While straightforward instructions and financial capacity increase perceived control and depress intentions, typical household barriers (renting status, limited capital for upgrades, and lack of technical know-how) lower them [27]. A TPB study on ethical consumerism in hospitality revealed that perceived behavioral control—relating to financial ability—was the primary predictor of willingness to pay for eco-certified hotels. In contrast, attitudes and social norms were not significant factors. This suggests that economic limitations, such as energy poverty, can outweigh pro-environmental attitudes when people lack the resources to act [41]. Therefore, we hypothesize that:

H4. *Perceived Behavioral Control has a significant influence on energy-saving intentions.*

2.5. Subjective Norms

Subjective norms relate to a person's perception of others' beliefs regarding their actions [25]. Subjective norms influence an individual's motivation to act, shaped by the perceived approval or disapproval of others who are deemed necessary to them [42]. Research in China indicates that behavior and intentions to save are influenced by norms, often through interaction with PBC and attitudes [28]. In the Arabic Gulf contexts, perceived social norms for adequate consumption of electricity are positively related to conservation intentions [43]. Since Jordan enjoys close family and communal bonds, normative influence is anticipated to be strong, particularly when there is social support for conservation and conservation salience [18]. Therefore, we hypothesize that:

H5. *Subjective norms have a significant influence on energy-saving intentions.*

2.6. Energy Saving Intentions and Behavior in Jordan

Research on energy-saving behavior has traditionally been conducted from the perspectives of psychology, sociology, and economics, with a focus on how individual intentions provide the basis for guiding behavior. TPB serves as a prototype model, while suggesting that attitudes, subjective norms, and perceived behavioral control operate jointly such that intentions predict future behavior [25]. Studies confirm that pro-environmental intentions are among the strongest indicators of household conservation habits, alongside moral norms and situational factors [44,45]. However, research consistently shows what represents the so-called "attitude–behavior gap" [46], such that positive environmental attitudes or intentions do not automatically become sustained energy conservation be-

havior by the presence of structural barriers, hardened habits, or countervailing motives. Despite such a gap existing, interventions focusing on the enhancement of the intentions-behavior connection—such as the construction of goals, feedback systems, and commitment techniques—have shown promise to improve conservation effectiveness [47,48].

Empirical studies also underscore the fact that intentions are a proximal motivator for behavioral change in numerous contexts. Experimental studies utilizing behavioral insights—like social norms comparisons and personalized feedback—document the fact that when people form explicit intentions to conserve energy, publicly visible decreases in consumption follow [49,50]. Systematic reviews of policies provide further support for the claim: both the Intergovernmental Panel on Climate Change and the International Energy Agency find that behavioral intentions are crucial to unlocking household-level mitigation potential when complemented by enabling environments that remove externality constraints [51,52]. Even while contextual barriers can affect outcomes, the evidence base consistently shows that elevated intentions increase the likelihood of adoption and persistence in conservation behavior. Therefore, we hypothesize that:

H6. *Energy-saving intentions have a significant influence on energy-saving behavior.*

2.7. The Moderating Effect of Energy Poverty

Energy poverty in Jordan is a multifaceted issue driven by poor energy efficiency and the presence of significant economic and social barriers that severely hinder access to suitable, modern, and sustainable energy services [53]. This condition fundamentally determines how the energy-poor choose to meet their basic energy needs [54], and critically impairs their agency and ability to decide how, or even if, to participate in pro-environmental actions [55]. In houses that use excessive energy due to structural issues like poor thermal insulation, air infiltration through windows, leaks, and dampness in walls, families often meticulously monitor their energy use primarily as a defensive strategy to manage unaffordable energy bills, a behavior born from necessity rather than environmental concern [56]. This context of scarcity creates a unique psychological and economic backdrop against which the core relationships of the TPB must be re-evaluated, as the very antecedents of intention and its translation into behavior are likely contingent on the severity of a household's energy poverty. Thus, while targeted financial interventions can potentially boost energy efficiency, which supports the emergent idea that scarcity can, under certain conditions, foster pro-social and pro-environmental behavior [2], it is theoretically imperative to posit that energy poverty operates not merely as a background variable but as a significant moderating force that alters the strength and direction of the relationships within the TPB framework. Therefore, based on the existing literature, we introduce energy poverty as a pivotal moderating factor that significantly influences households' energy-saving intentions and their subsequent translation into concrete behaviors.

The constant financial strain and thermal discomfort associated with energy poverty may heighten the salience of energy costs, potentially strengthening the relationship between positive attitudes towards saving and the formation of a behavioral intention, as energy conservation becomes directly linked to urgent economic necessity and well-being [2,56]. Conversely, the same pressures can create a sense of helplessness and restricted agency, potentially weakening the relationship between perceived behavioral control and intention; even if an individual believes in the benefits of saving energy (positive attitude) and feels social pressure to do so, a profound lack of resources and options may lead them to believe that such actions are beyond their personal control, thereby dampening their intention [9,55]. Similarly, the role of subjective norms may be altered, as households in severe energy poverty may prioritize survival strategies and informal coping mechanisms over complying with broader societal expectations regarding energy use [7,21]. Conse-

quently, the moderation proposition of energy poverty is grounded in the recognition that the formation of intention is not a universal process but is deeply contextualized by material circumstances [26,43]. Therefore, the following hypothesis is proposed:

H7. *Energy poverty moderates the relationships between attitudes (H7.1), perceived behavioral control (H7.2), subjective norms (H7.3), and energy-saving intentions.*

Furthermore, a strong intention to save energy may fail to materialize into actual behavior among energy-poor households due to the intention-behavior gap, which is exacerbated by structural and financial constraints [46]. For instance, an individual may have a high intention to conserve electricity but reside in a home with obsolete, energy-intensive appliances and inadequate insulation, making significant reductions in consumption virtually impossible without external capital investment, thus severing the link between intention and behavior [20,22]. Energy poverty creates a context in which intentions are often overridden by immediate needs for thermal comfort or by the inability to afford upfront costs for efficiency upgrades, even when the long-term savings are understood [18,56]. Therefore, hypothesizing that energy poverty moderates the relationship between energy-saving intentions and energy-saving behavior is essential, as it acknowledges that translating motivation into action is not automatic but is critically dependent on the capacity to act, which is systematically eroded by the condition of energy poverty itself [24,27]. Accordingly, the following hypothesis is proposed:

H8. *Energy poverty moderates the relationships between energy-saving intentions and energy-saving behavior.*

Based on the previous discussion, the conceptual framework of this study is illustrated in Figure 1, which shows the path directions and the influence of the study's variables.

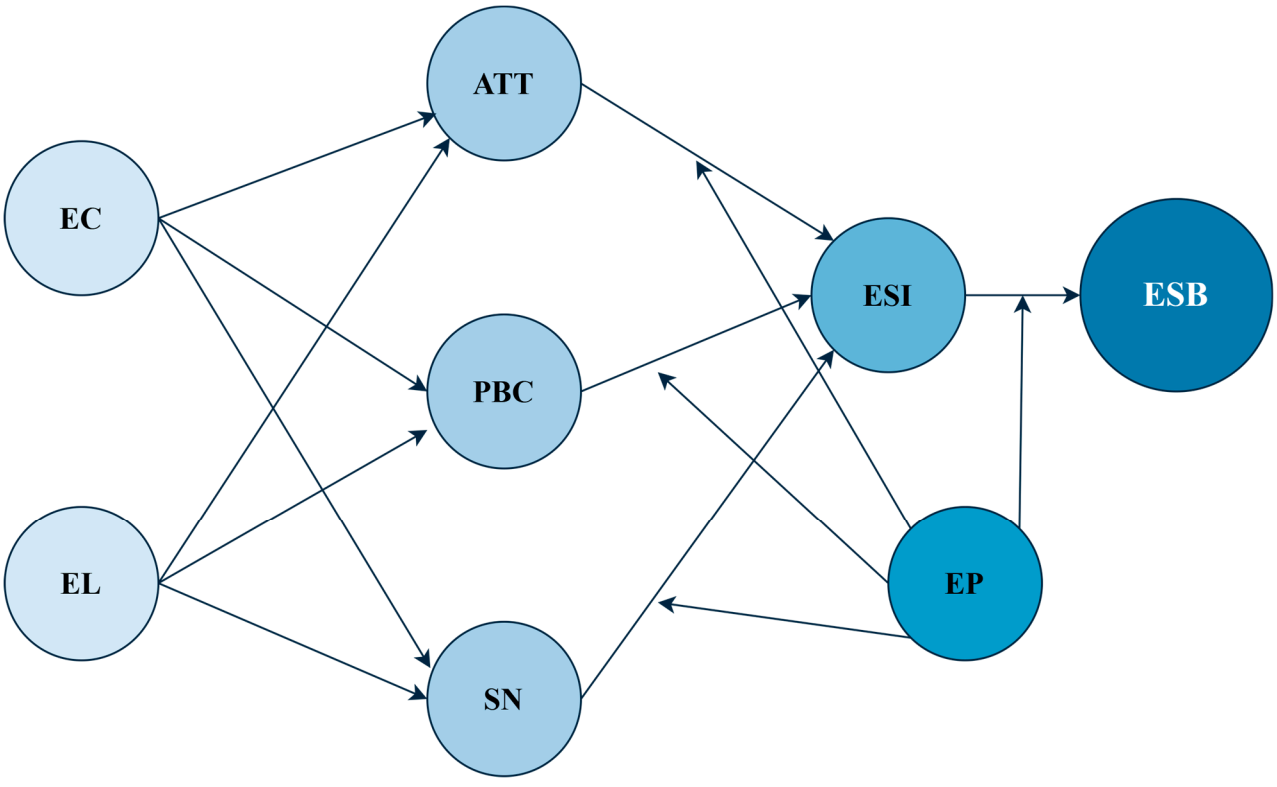

Figure 1. Conceptual model of energy-saving behavior.

3. Materials and Methods

3.1. Research Design

The study employed a cross-sectional, quantitative design and used a structured, self-administered questionnaire. The research theory employed the TPB, which emphasizes the roles of attitudes, subjective norms, and perceived behavioral control in determining behavioral intentions [25]. The survey approach was employed because it is well-suited to measure individual perceptions, attitudes, and intentions toward energy-saving measures. Afterward, the collected data were analyzed through the structured equation modeling using the SmartPLS 4.1 software [57].

3.2. Instrument Development

Survey instrument development drew from earlier literature on TPB application in energy-saving behavior [58]. The constructs included attitudes towards saving energy, subjective norms, perceived behavioral control, and behavior intention. Each construct was measured through a multiple-item scale derived from established TPB questionnaires. Responses were captured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), making attitudinal and perceptual dimensions measurable [59]. The research also introduced a new construct, energy poverty, as a moderator. The authors constructed the items for this construct after a thorough review of the literature on energy poverty and affordability across developing economies [21,60,61]. The final instrument included constructs consistent with the Theory of Planned Behavior and incorporated additional factors. Specifically, the scale had three items in attitudes towards energy-saving (ATT = 3), two items in environmental concerns (EC = 2), two items in eco-literacy (EL = 2), two items in subjective norms (SN = 2), three items in perceived behavioral control (PBC = 3), three items in electricity-saving intentions (ESI = 3), and three items in electricity-saving behavior (ECB = 3). Table 1 shows the constructs used in the study and their respective references.

Table 1. Constructs and measurement items.

Constructs			Measurement Items
ATT	Attitude [27,40,62]	ATT1	Saving electricity at home is necessary.
		ATT2	Saving home energy helps improve the air environment.
		ATT3	Saving home energy is important to reduce CO_2 emissions.
EP	Energy Poverty [19]	EP1	My household was able to afford keeping the home at a comfortable temperature (warm enough in winter and cool in summer).
		EP2	My household has experienced financial difficulties, resulting in late bill payments (inability to pay utility bills on time) over the past twelve months.
		EP3	My household members avoid using heating or cooling because of its cost, even when it is necessary for health or comfort.
		EP4	My household experienced electricity disconnection or service cut-off due to unpaid bills or inability to pay
INT	Intention [27,63]	INT1	I intend to save electricity in my home.
		INT2	I'd like to turn off the light in an empty room.
		INT3	I'd like to reduce the use of cooling or heating equipment during times when the weather is neither very hot nor very cold.

Table 1. *Cont.*

Constructs		Measurement Items	
PBC	Perceived Behavioural Control [27,40,62]	PBC1	I know what I should do to save electricity.
		PBC2	I know how to use electricity efficiently.
		PBC3	I can save electricity easily.
ESB	Electricity-saving Behavior [64–66]	ESB1	I always turn off the light in time.
		ESB2	I always turn off the TV or air conditioner when the room is empty.
		ESB3	I always set the air conditioner to the right temperature, not the lowest or highest setting.
SN	Subjective Norms [27,40,67]	SN1	I save electricity because my neighbors do the same.
		SN2	My family members encourage me to save electricity.
		SN3	My friends encourage me to save electricity.
EC	Environmental Concern [68]	EC1	The natural balance is fragile and vulnerable to damage.
		EC2	When nature is disturbed by humans, there are often catastrophic consequences.
		EC3	Human beings must live in harmony with nature in order to survive.
EL	Eco-literacy [69]	EL1	I prefer to check the eco-labels and certifications on energy-efficient appliances before I purchase
		EL2	I want to gain a deeper understanding of the inputs, processes, and impacts of appliances before I make a purchase.
		EL3	I understand the environmental phrases and symbols on the product package.

3.3. Data Collection Procedure

Data were collected between 18 May 2025 and 31 July 2025 via an online questionnaire administered via Google Forms. Questionnaire links were distributed on popular social media platforms in Jordan, i.e., Facebook, WhatsApp, and LinkedIn. This method provided sufficient exposure to the Jordanian population who actively use such platforms. Both convenience sampling and snowball sampling were used in combination to achieve high response rates. Early participants were encouraged to share the survey URL with coworkers in their circles who might be interested in responding, thereby expanding the sample population [70].

The English version of the survey questionnaire was initially composed, followed by translation into Arabic. Then, a back-translation method was employed to ensure linguistic and conceptual equivalence, as recommended in cross-cultural survey research [71]. A pilot study was also conducted before large-scale deployment to measure the clarity of items and the reliability of constructs. Cronbach's alpha (α) coefficients for all the scales were satisfactory, greater than the minimum of 0.70, indicating high internal consistency. At the end of the data collection period, a total of 396 complete and valid responses were gathered. The demographic characteristics of the respondents are presented in Table 2.

The gender distribution indicates that female participants constitute 65.7% (n = 260), whereas males account for the remaining 34.3% (n = 136). The group is predominantly young, with nearly half (49.7%) aged between 18 and 24 years. The group is highly educated, with the majority (77.8%) holding a bachelor's degree, which correlates with the largest proportion of respondents (43.7%) identifying as students. Reflecting this demographic profile, the most common monthly income falls within the middle range of 300–599 units (34.1%), indicative of a concentration of participants within lower to middle

socioeconomic brackets. The sample comprises a diverse array of employment statuses, including employed individuals (37.6%), unemployed or retired individuals (18.7%), and students (43.7%).

Table 2. Demographic Characteristics.

Variable	Category	Frequency	Ratio
Gender	Male	136	34.3
	Female	260	65.7
Age Range	18–24	197	49.7
	25–34	57	14.4
	35–44	72	18.2
	45–54	47	11.9
	55+	23	5.8
Education	Diploma or less	43	10.9
	Bachelor's degree	308	77.8
	Master's or above	45	11.4
Work status	Full-time employee	107	27.0
	Part-time employee	23	5.8
	Self-employed	19	4.8
	Student	173	43.7
	Unemployed	46	11.6
	Retired	28	7.1
Income Level	Less than 300	63	15.9
	300–599	135	34.1
	600–899	89	22.5
	900–1199	58	14.6
	1200 or more	51	12.9
Total		396	100%

4. Results

4.1. Measurement and Structural Model Assessment

In evaluating the measurement model, the reliability and validity of each construct were assessed. The analysis was conducted using SmartPLS 4.1 with 5000 bootstrap resamples and one-tailed tests for directional hypotheses. The moderating effects of Energy Poverty were tested using the product-indicator approach.

According to Table 3 three items, EC1, EL3, and SN3, were dropped since they have outer loadings below the recommended threshold value of 0.7 [72]. Such purification is standard in PLS-SEM to ensure that only strong indicators are used in construct measurement [73]. The retained items had loadings ranging from 0.814 to 0.939, all of which were significant ($p < 0.001$), indicating they were also appropriate for inclusion in the model assessment.

The internal homogeneity was determined based on (α) and composite reliability (CR) values, both of which were above 0.7, which is above the recommended threshold level of 0.7 by Nunnally and Bernstein [74]. Convergent validity was demonstrated because the averages of variance extracted (AVE) of each construct exceeded the value of 0.5 [75], ranging from 0.757 to 0.842, indicating that the constructs accounted for over half of the variance in the respective indicators.

Furthermore, the discriminant validity measurement was tested using two methods. First, the Fornell-Larcker criterion (Table 4) indicated that the square root of the AVE of each construct (diagonal values) was higher than the correlation of the respective construct with another, fulfilling this requirement [76]. Second, the HTMT ratio (Table 5) showed

that all values were below a conservative threshold of 0.85 [77], further supporting the discriminant validity. These rigorous tests ensure that every construct in the study model is empirically distinct from the others.

Table 3. Outer Loadings and Measurements cut-off.

Construct	Item	Outer Loadings	Variance Inflation Factor	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Attitude (ATT)	ATT1	0.853	1.593	0.842	0.903	0.757
	ATT2	0.888	2.681			
	ATT3	0.870	2.604			
Environmental Concerns (EC)	EC2	0.867	1.593	0.758	0.890	0.803
	EC3	0.924	1.593			
Eco-Literacy (EL)	EL1	0.860	1.444	0.713	0.874	0.776
	EL2	0.901	1.444			
Electricity-saving Behavior (ESB)	ESB1	0.920	2.974	0.885	0.929	0.814
	ESB2	0.903	2.670			
	ESB3	0.882	2.215			
Electricity-saving Intentions (ESI)	ESI1	0.928	3.607	0.906	0.941	0.842
	ESI2	0.939	3.937			
	ESI3	0.885	2.333			
Perceived Behavioral Control (PBC)	PBC1	0.917	2.592	0.885	0.928	0.812
	PBC2	0.912	2.744			
	PBC3	0.874	2.300			
Subjective Norms (SN)	SN1	0.931	1.423	0.706	0.866	0.764
	SN2	0.814	1.423			

Table 4. Fornell-Larcker criterion.

Construct	ATT	EC	EL	EP	ESB	ESI	PBC	SN
ATT	0.870							
EC	0.601	0.896						
EL	0.535	0.530	0.881					
EP	0.274	0.359	0.286	1.000				
ESB	0.680	0.570	0.445	0.371	0.902			
ESI	0.594	0.499	0.432	0.346	0.666	0.918		
PBC	0.505	0.412	0.376	0.432	0.560	0.532	0.901	
SN	0.606	0.392	0.429	0.318	0.509	0.506	0.527	0.874

Table 5. Heterotrait-monotrait ratio (HTMT)—Matrix.

Construct	ATT	EC	EL	EP	ESB	ESI	PBC	SN
ATT								
EC	0.729							
EL	0.674	0.705						
EP	0.291	0.409	0.337					
ESB	0.776	0.686	0.557	0.394				
ESI	0.665	0.594	0.532	0.362	0.745			
PBC	0.573	0.489	0.467	0.459	0.631	0.587		
SN	0.764	0.495	0.592	0.354	0.619	0.601	0.644	

The structural model has been tested using path coefficients, significance levels, and predictive power. The values of the variance inflation factor (VIF) (see Table 3), which are all lower than 5, do not indicate any problematic multicollinearity between the constructs defining the predictors [72]. The model demonstrated good fit based on the SRMR value of 0.061, which is below the recommended threshold of 0.08 [77]. Finally, the explanatory power of the model, as indicated by the R-square (R^2) value, was moderate to substantial, representing moderate to high predictive adequacy for behavioral intention models [78]. The antecedents accounted for 47.6% of the variance in ESI, which in turn accounted for 48.5% of the variance in ESB.

4.2. Hypotheses Testing Results

As shown in Table 6, most of the study hypotheses are supported by the path coefficients and their corresponding significance levels. EC had a significant effect on the three TPB antecedents: ATT ($\beta = 0.442$, $p < 0.001$), PBC ($\beta = 0.296$, $p < 0.001$), and SN ($\beta = 0.229$, $p < 0.001$), which support the hypotheses H1.1, H1.2, and H1.3. Similarly, high positive effect of EL on ATT ($\beta = 0.300$, $p < 0.001$), PBC ($\beta = 0.219$, $p < 0.001$) and SN ($\beta = 0.308$, $p < 0.001$) supporting hypotheses H2.1, H2.2, and H2.3. These results align with other studies that demonstrate environmental awareness and knowledge are key factors in forming pro-environmental attitudes and perceived abilities [20,49]. Moreover, TPB antecedents were significantly predictive of ESI, with ATT ($\beta = 0.293$, $p < 0.001$), PBC ($\beta = 0.233$, $p < 0.001$), and SN ($\beta = 0.107$, $p = 0.043$, 95% CI [0.005, 0.217]), and all having a positive effect, which supports hypotheses H3, H4, and H5. Notably, ATT emerged as the strongest predictor of intentions, according to the results. ESI, in turn, made a significant contribution to the actual ESB ($\beta = 0.532$, $p < 0.001$), which confirmed H6, which is consistent with the basic assumption of TPB [25].

Table 6. Path Coefficients.

Hypothesis	Path	Coefficient	T Values	*p* Values	CI 2.5%	CI 97.5%	f^2	Result
H1.1	EC -> ATT	0.442	7.843	0.000	0.327	0.546	0.245	Supported
H1.2	EC -> PBC	0.296	4.970	0.000	0.178	0.411	0.079	Supported
H1.3	EC -> SN	0.229	3.917	0.000	0.114	0.343	0.048	Supported
H2.1	EL -> ATT	0.300	6.131	0.000	0.208	0.399	0.113	Supported
H2.2	EL -> PBC	0.219	4.014	0.000	0.113	0.325	0.043	Supported
H2.3	EL -> SN	0.308	5.550	0.000	0.200	0.415	0.088	Supported
H3	ATT -> ESI	0.293	4.842	0.000	0.175	0.411	0.084	Supported
H4	PBC -> ESI	0.233	4.492	0.000	0.130	0.334	0.060	Supported
H5	SN -> ESI	0.107	2.024	0.043	0.005	0.217	0.012	Supported
H6	ESI -> ESB	0.532	7.823	0.000	0.395	0.662	0.373	Supported
H7.1	EP × ATT -> ESI	−0.174	3.665	0.000	−0.267	−0.080	0.041	Supported
H7.2	EP × PBC -> ESI	−0.003	0.061	0.951	−0.098	0.109	0.000	Rejected
H7.3	EP × SN -> ESI	0.026	0.585	0.558	−0.067	0.109	0.001	Rejected
H8	EP × ESI -> ESB	−0.127	2.394	0.017	−0.227	−0.020	0.036	Supported

Regarding the impact of EP, the results revealed a significant direct effect on both ESI ($\beta = 0.099$, $p < 0.05$) and ESB ($\beta = 0.154$, $p < 0.001$). More precisely, and even though EP did not have any significant moderating effects in the relationship between PBC ($p = 0.951$) or SN ($p = 0.558$) with intentions, which leads to the rejection of (H7.2 & H7.3), it significantly moderated the relationship between ATT and ESI ($\beta = -0.174$, $p < 0.001$), which supports (H7.1) and that between ESI and ESB ($\beta = -0.127$, $p = 0.017$), which supports (H8). Such results suggest that economic constraints may influence positive environmental attitudes and hinder the conversion of intention into behavior [20]. This complements the analysis

on EP, which revealed that financial constraints are a serious barrier to consider in the sustainable use of energy [20].

This pattern of results reveals the dual nature of EP. The positive direct effects demonstrate that the constant financial strain of EP serves as a powerful motivator for energy-saving intentions and behaviors, driven by mere economic necessity [2,56]. However, the negative moderating effects uncover a more complex psychological reality. We hypothesize that scarcity fundamentally alters decision-making processes. While EP forces action, it can also deplete the cognitive and emotional resources required for planned behavior [55]. This means that for individuals in energy poverty, the usual psychological process of acting on a positive ATT or a firm intention ESI is disrupted. The overwhelming focus on immediate cost-saving (a direct effect) can "crowd out" the influence of broader environmental attitudes, weakening the ATT→ESI link. Similarly, the chronic stress of scarcity and the constraints of their housing situation [20,22] can widen the intention-behavior gap [46], making it harder to consistently act on even the strongest intentions to save (thus weakening the ESI→ESB link). In essence, energy poverty compels saving through necessity while simultaneously undermining the very cognitive pathways that typically guide pro-environmental action.

The model's predictive power was comprehensively assessed using multiple indices. The f^2 effect sizes (Table 5) reveal that the ESI -> ESB relationship (0.373) had a large practical effect, while EC -> ATT (0.245) and EL -> ATT (0.113) showed medium effects. The PLSpredict procedure with 10 folds demonstrated substantial predictive relevance with Q^2 predict values of 0.340 for ESB and 0.324 for ESI, both indicating large predictive relevance according to established guidelines (Q^2 > 0.25 = large; Q^2 > 0.15 = medium; Q^2 > 0.02 = small) [74]. The low RMSE values (0.821 for ESB and 0.829 for ESI) and MAE values (0.647 for ESB and 0.619 for ESI) further confirm the model's strong predictive accuracy. These results provide robust evidence of the model's explanatory and predictive power beyond traditional R^2 measures. Figure 2 shows the measurement and structural results of the conceptual framework of this study.

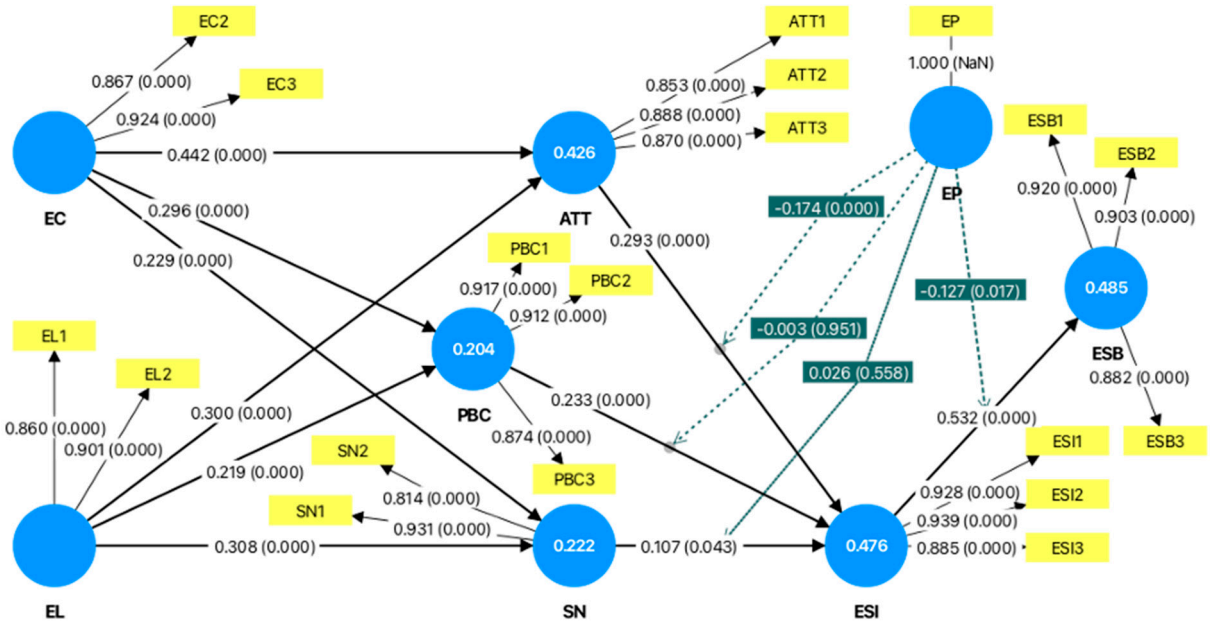

Figure 2. Measurement and Structural Results.

5. Discussion

The findings of this study provide empirical support for the extended TPB theory in explaining energy-saving intentions and behaviors within the context of socio-economic and climatic surroundings in Jordan. The results confirm the core evidence of the TPB, demonstrating that Jordanians' attitudes, subjective norms, and perceived behavioral control are significant predictors of energy-saving intentions, which in turn strongly predict self-reported behavior [25]. This aligns with a body of international research applying the TPB to pro-environmental behaviors, including energy conservation [26–28]. However, adding additional constructs—environmental concern, eco-literacy, and energy poverty—reveals a more detailed view of the factors influencing energy conservation in a middle-income country facing significant economic and environmental challenges, such as Jordan.

The analysis confirms that both environmental concern and eco-literacy serve as significant antecedents to the core TPB constructs. Environmental concern exerted a strong influence on attitudes, perceived behavioral control, and subjective norms. This finding is consistent with prior literature suggesting that a sense of responsibility towards environmental problems can shape personal norms and attitudinal assessments, thereby influencing behavioral intentions [30,31]. Similarly, eco-literacy was found to affect all three TPB components positively. This highlights the argument that knowledge, particularly when it is rooted in an understanding of sustainability and community action, is not an isolated factor but one that operates by enhancing positive attitudes, strengthening perceived control, and reinforcing the perceived expectations of others [35,38]. In the Jordanian context, these results align with studies indicating a generally high level of environmental awareness among the populace, although practical barriers often hinder it [33,34]. Our model demonstrates that this awareness is indeed channeled into the cognitive foundations of behavioral intention.

Among the traditional TPB variables, attitude emerged as the strongest direct predictor of energy-saving intention, a result that is consistent with previous research in Jordan on renewable energy adoption [19]. This suggests that fostering positive evaluations of the benefits of energy conservation—such as reduced costs and environmental protection—remains a crucial avenue for intervention. Perceived behavioral control also showed a significant, positive relationship with intention, highlighting that when individuals feel they have the means and ability to save energy, they are more likely to form an intention to do so [25,27]. The effect of subjective norms, while statistically significant, was the weakest among the three. This relatively small influence suggests that, while social pressure exists, it may be a less potent motivator of energy-saving behavior in Jordan than personal attitudes and control beliefs. This finding partially contrasts with research in other collective societies, such as the Gulf states, where norms were more strongly correlated with intentions [43], indicating potential cultural or contextual nuances within the MENA region that warrant further investigation.

An essential contribution of this study is the introduction and testing of energy poverty as a moderating variable. The results reveal its complex and constraining role. In addition to its restraining moderating role, the model also shows a positive direct effect of energy poverty on both intentions and behavior. This apparent contradiction reflects the dual nature of scarcity. On the one hand, energy-poor households often have to cut back on consumption due to financial necessity, consistent with evidence that low-income households adopt frugal energy practices as a survival tactic rather than an environmentally friendly choice [79]. Moreover, low-income people react to burdens by lowering their living standards, which, with time, becomes a normal lifestyle; even heating all rooms would look luxurious [80]. This need-driven motivation explains the positive direct link between energy poverty and energy-saving intentions and actions. On the other hand, scarcity

research indicates that financial strain reduces cognitive capacity, diminishes executive control, and interferes with planned decision-making processes [81]. Additionally, the energy poor face conditions where they cannot access information on energy poverty, pricing, and solutions, or participate in policies related to energy, housing, climate change, and finances [55]. Therefore, while energy-poor households may intend to save energy, the ongoing stress of deprivation, poor housing conditions, and limited access to efficient technologies weaken the processes through which attitudes influence intentions, which in turn influence behavior. This dual mechanism clarifies why energy poverty both promotes energy-saving behavior out of necessity and undermines the psychological processes that typically support deliberate, consistent conservation. Energy poverty significantly weakened the relationship between positive attitudes and intentions. This indicates that even when individuals hold favorable attitudes towards energy conservation, the immediate financial strain and poor housing conditions associated with energy poverty can inhibit the formation of a firm intention to act [20,54,55]. Furthermore, energy poverty negatively moderated the relationship between intentions and actual behavior, providing empirical evidence for the "attitude-behavior gap" in a context of material deprivation [46]. For energy-poor households, translating intentions into concrete actions is hindered by structural constraints, such as the inability to invest in energy efficiency upgrades or to reside in well-insulated homes [22,56]. These findings can be powerfully reinterpreted through the lens of the Capability Approach [82,83]. This approach posits that well-being should be assessed not by income alone, but by an individual's real opportunities (capabilities) to (functionings) achieve valuable states of being and doing [83]. Energy poverty, in this view, represents a critical constraint on capabilities. According to Day et al. [84], it limits the "practical opportunities" available to individuals, such as the capability to live in a thermally comfortable home or to invest in energy-efficient appliances, regardless of their intentions or attitudes. The empirically observed moderating effect demonstrates that energy poverty directly impairs the ability to translate intentions into energy-saving behavior, thereby restricting individuals' freedom to live the lives they value [85,86].

Interestingly, energy poverty did not moderate the effects of PBC or subjective norms on intentions. This suggests that the perception of control and social influence may be less susceptible to the diminishing impact of economic constraints than an individual's attitudinal drive. This aligns with the Capability Approach's emphasis on a plurality of factors—personal, social, and environmental—that affect an individual's ability to convert resources into functioning [83]. An individual might perceive social support and feel generally capable, but the very real environmental factor of living in an energy-inefficient home (a form of "environmental conversion factor") can still cripple their effective capability to act [84,87]. Overall, the significant moderating effect of energy poverty reveals that the journey from a positive attitude to actual energy-saving behavior is not straightforward for a substantial portion of the Jordanian population. Therefore, a holistic approach that integrates psychological, educational, and economic strategies is essential for promoting sustainable energy use and building resilience in the face of climate challenges, such as the extreme heatwaves Jordan increasingly experiences [11,20].

The results of this study also support and provide evidence from neighboring MENA countries. In Saudi Arabia, research into young people's energy-saving behavior [88] has revealed that subjective norms, awareness campaigns, and habitual practices are strong predictors of attitudes and intentions, reflecting a strong social and cultural dimension in the formation of energy-saving dispositions. Conversely, our findings for Jordanian households suggest that attitudes and perceived behavioral control are more influential than subjective norms, indicating that personal evaluations and perceived capability may play a comparatively stronger role than social pressure in this context. Within Jordan itself,

studies drawing on the TRA and related behavioral frameworks [19,89,90] consistently report that attitudes emerge as the dominant predictor of purchase intentions for energy-saving or energy-efficient products. At the same time, environmental or energy awareness serves as a key antecedent to both attitudes and subjective norms. These patterns closely correspond with our finding that attitudes emerged as the strongest driver of energy-saving intentions. Eco-literacy and environmental concern significantly influenced the core TPB constructs. At the same time, recent work on the adoption of energy-efficient appliances in Jordan [91] identifies low income, limited awareness, and financial barriers as significant constraints on sustainable consumption, reinforcing our result that economic conditions—here conceptualized as energy poverty—substantially condition whether households can act on their pro-environmental attitudes and intentions. Taken together, these regional studies suggest that while TPB-based determinants, such as attitudes, subjective norms, and awareness, are broadly relevant across the MENA region, the balance between these determinants and the salience of structural constraints differs across contexts. Our contribution extends the regional literature by explicitly modeling energy poverty within a behavioral framework and demonstrating how it moderates the psychological pathways underlying household energy-saving behavior in a climate-vulnerable, middle-income setting in the MENA region.

6. Conclusions

This present study contributes to new evidence on the drivers of household energy-saving behavior in Jordan by extending the Theory of Planned Behavior through the inclusion of environmental concern, eco-literacy, and energy poverty. The results confirm that attitudes, perceived behavioral control, and subjective norms exert a significant impact on molding intentions, with attitudes emerging as the strongest predictor. Environmental concern and eco-literacy are also influential moderators that reinforce the core TPB constructs, thereby underlining the necessity for public investment in environmental knowledge and awareness.

Adding energy poverty to the model introduces an important dimension for household behavior. On the one hand, energy poverty may motivate energy-saving measures out of necessity; on the other hand, it also weakens the pathways by which positive attitudes are translated into intentions and how intentions are translated into actual behavior. Households may therefore understand and value energy conservation but remain limited by inadequate housing, inefficient appliances, or financial constraints. These results emphasize the limited effectiveness of strategies that focus on information campaigns or behavioral nudges.

The results indicate that to make saving energy both feasible and equitable, a set of actionable recommendations is called for: Firstly, targeted subsidies or micro-financing schemes should be scaled up to enable low-income households to replace inefficient appliances, invest in basic insulation, or install energy-efficient cooling systems, especially before peak summer demand. Secondly, national programs could offer free or low-cost home energy audits through partnerships with municipalities or NEPCO, providing tailored guidance aligned with the actual constraints of households. Thirdly, improving housing quality should be part of Jordan's energy and climate resilience strategy, which involves retrofitting older buildings, incentivizing landlords to upgrade their rentals, and implementing minimum thermal performance standards. Fourthly, schools, community centers, and local NGOs should incorporate energy literacy modules into their activities, linking environmental messaging with practical demonstrations, so that households can translate awareness into realistic action. Finally, coordinated communication strategies during heatwaves-such as more explicit guidance on temperature settings, time-of-day guidance,

and feedback mechanisms—can support households in managing consumption without compromising health. Future research is needed to explore precisely how specific interventions, such as appliance replacement programs, building retrofit schemes, or targeted financial support, influence the intention-behavior link across energy-poor households. Longitudinal and intervention-based studies across the MENA region would help clarify how climate change impacts and economic vulnerability interact with behavioral drivers in the long term.

By situating household energy-saving behavior within the pressures of climate extremes and energy poverty, this study underlines the need for integrated psychological, socio-economic, and structural strategies toward a just and effective energy transition in Jordan.

Limitations

During the preparation and implementation of this study, we acknowledge three limitations. First, this paper is based on primary data collected through a survey. The data collection method relied on non-probabilistic sampling, which may limit the generalizability of the results to the broader Jordanian population. Second, our online survey was limited to respondents who own a mobile phone or a personal computer with internet access, restricting our reach to a specific segment of Jordanian society. Third, because all our survey questions are closed-ended, we did not collect additional information that would allow participants to provide more details about their experiences related to the study's topics. Furthermore, for a better understanding of behavior, qualitative data collection will enable researchers to gain deeper insights into people's living experiences.

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Abbreviations

The following abbreviations are used in this manuscript:

TPB	Theory of Planned Behavior
ATT	Attitude
SN	Subjective Norms
PBC	Perceived Behavioral Control
EC	Environmental Concern
EL	Eco-Literacy
EP	Energy Poverty

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