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Do Pro-Environmental Factors Lead to Customers' Purchase Intention of Home Energy Management System? The Moderating Effects of Energy-Efficient Habits

Maryam Zidehsaraei[1,*], Minoo Zidehsaraei[2] and Kourosh Esfandiar[3]

[1]*Department of Management, University of Guilan, Iran*

[2]*Department of Architecture, University of Guilan, Iran*

[3]*School of Business and Law, Edith Cowan University, Australia*

Abstract: Environmental challenges, encompassing climate change and global warming, compel consumers to alter their consumption habits. Although there has been a notable surge in consumer awareness regarding pro-environmental practices, especially concerning home energy, there remains a lack of comprehensive research exploring the factors affecting consumers' willingness to adopt or invest in home energy management system (HEMS) technology. Notably, there have been no studies focused on the factors influencing HEMS purchase intentions (PI) in the Iranian context. Grounded in the theory of planned behavior (TPB) and the norm activation model, this research delves into the PI of Iranian households regarding HEMS, categorizing it as a type of eco-friendly behavior. It specifically analyzes the influence of factors such as attitude (ATT), social norms (SN), perceived behavioral control (PBC), awareness of consequences (AOC), personal norms (PN), and energy-efficient habits (EEH). Moreover, this research scrutinizes the potential moderating effects of EEH on the association among ATT, PBC, and PI. Using structural equation modeling, an innovative integrated model was tested based on data collected from 220 Iranian residents. The findings revealed that ATT, SN, AOC, and EEH significantly contribute to the PI of HEMS among Iranians. Additionally, both AOC and SN were found to influence PN. These insights offer a fresh perspective on the pro-environmental determinants shaping the HEMS purchase decisions of Iranian consumers.

Keywords: home energy management system (HEMS), social norms (SN), personal norms (PN), awareness of consequences (AOC), energy-efficient habits (EEH), purchase intentions (PI)

1. Introduction

Humans' ability to generate and store energy has partially fueled the world's significant economic growth over the last 200 years. Access to energy is vital for a society's development and serves as a pivotal indicator of the standard of living [1]. However, the rising energy needs to meet the demands of the expanding human population have led to environmental concerns, affecting all human activities and heightening attention to these environmental issues [2–5].

Given this context, there has been a surge in academic research over the past decade, focusing on the environmental implications of energy consumption, notably climate change [6–11]. The World Economic Forum's annual report from 2019 identified climate change as the most significant global risk to the planet [12]. The combustion of fossil fuels such as coal, oil, and natural gas releases carbon dioxide (CO_2) and other greenhouse gases (GHGs), which trap heat in the atmosphere. These nonrenewable fuels account for approximately 80% of global energy consumption, positioning them as primary contributors to global warming and climate change [13].

Globally, buildings and their associated activities contribute to approximately 25–40% of global energy consumption and account for 30–40% of GHGs emitted into the atmosphere worldwide [14]. Furthermore, 22% of the total annual energy consumption from buildings is attributed to households [15]. This escalating energy consumption in households has garnered significant attention, making it a principal contributor to environmental changes, particularly global GHG emissions [16, 17]. As a result, there has been a pronounced shift toward energy-smart technologies to reduce household energy usage [18]. Consequently, the home energy management system (HEMS) has attracted considerable attention from both practitioners and scholars [19–21].

*Corresponding author: Maryam Zidehsaraei, Department of Management, University of Guilan, Iran. Email: mmzidehsaraei@msc.guilan.ac.ir

The majority of energy consumption in residential buildings is allocated to air conditioning, cooling, heating, and lighting [11]. In the context of this study, Iran's residential sector contributes to 20–33% of the country's total energy usage and CO_2 emissions [22]. Confronted with pressing environmental challenges, there's been a rise in public consciousness regarding the ecological consequences of their consumption behaviors, leading to a shift toward pro-environmental behaviors [23]. People are now more inclined to adopt environmentally friendly practices such as waste separation, reduced water usage, utilizing public transport, and embracing eco-technologies [24]. Consequently, there's a growing preference for sustainable products and services that boast minimal environmental impact, zero CO_2 emissions, or those that are biodegradable and ethically sourced [25]. This trend has spurred electrical and computer companies to invest more in energy-efficient products.

A prime example of sustainable products that leverage technological innovations to minimizing human influence on the ecosystem is the HEMS, also known as a "smart home." This system is gaining traction in Iran, as recent academic research among Iranian scholars suggests [16, 17, 26]. HEMS operates by monitoring energy use and delivering feedback to users through an integration of hardware and software, enabling them to manage their energy consumption more effectively by adjusting their behavior [20]. While the HEMS market is poised for significant growth in the upcoming years, there remains a limited understanding of the psychological factors motivating users to adopt these systems. Despite the evident advantages of HEMS, including cost savings, automation, and environmental benefits, many individuals might still be hesitant to embrace and invest in such systems [20, 27].

One way to gauge interest in the adoption of HEMS is by studying people's purchase intentions (PI). This insight will also deepen our understanding of the factors that deter consumers from embracing this technology. Although numerous studies have explored factors influencing consumers' green purchase behaviors [6–8, 28–31], few have specifically targeted HEMS. While extensive studies on HEMS have been carried out in developed nations [20], there are insufficient studies addressing HEMS in developing nations, with Iran, the focus of this study, being a prime example.

In recent decades, Iran has seen rapid urbanization. Data indicates that 75.87% of Iran's population resided in urban areas in 2020 [32]. This swift urban expansion, combined with the convenient availability of energy sources, has led to a surge in energy consumption by Iranian households. Consequently, the residential sector enumerates 20–33% of Iran's overall energy use and CO_2 emissions [26]. Given advancements in HEMS and smart appliances, coupled with an increased awareness of environmental concerns among Iranians, there's a growing inclination to adopt these technologies to cut energy consumption and costs [33]. Understanding the intent to purchase HEMS is crucial. This study uses PI as a stand-in for actual behavior since analyzing the real actions of consumers unfamiliar with HEMS is challenging. Moreover, in pro-environmental research, "intention" is often favored over actual behavior metrics [34].

In summary, research has demonstrated the predictive role of attitude (ATT), social norms (SN), and perceived behavioral control (PBC) in green purchase intentions (GPI). However, these findings have been inconsistent [29, 35–39], and their applicability to HEMS among Iranian customers has yet to be explored. Similarly, the role of awareness of consequences (AOC) on personal norms (PN) and the impact of PN on GPI have been identified in the eco-friendly products context, but these findings too show inconsistencies [37, 40–42]. Additionally, the influence of AOC on the PN of Iranian HEMS customers and the subsequent impact of PN on their PI for HEMS remains an uncharted territory. The relationship between SN and PN in the realm of green products is also marked by inconsistent findings [43] and has not been examined within the Iranian HEMS customer context. Moreover, there's a noticeable absence of research on the effect of energy-efficient habits (EEH) on PI and PBC for this demographic. There's also a lack of exploration into the moderating of EEH in the dynamic among ATTs, PBC, and PI. Addressing these gaps can provide valuable insights into Iranian customers' purchase behaviors and their perceived control over HEMS. Consequently, this study seeks to bridge these gaps by delving into these unexamined aspects among Iranian HEMS customers.

This study aims to explore customer's PI for HEMS by integrating elements from both the norm activation model (NAM) and the theory of planned behavior (TPB). This approach addresses the call from Chen et al. [20] for more research that explores various factors influencing the adoption, payment, and inhabitance of HEMS by customers. Both models are valuable for examining pro-environmental behavioral intentions. TPB posits that human behavior primarily originates from rational or self-interest motivations influenced by SN, ATTs, and PBC [44]. Meanwhile, the NAM, as defined by Schwartz [45], suggests that prosocial or other-interest-driven motives can predict individual behaviors, such as PI. Stern [46] further elaborated on the NAM, emphasizing components like ascription of responsibility (AOR), AOC, and PN as drivers for pro-environmental behavioral intentions.

Another distinction between the two mentioned models is their treatment of PN. In the NAM, PN can be regarded as intrinsic factors linked to environmentally sustainable behavior, whereas in the TPB, SN are externally influenced by regulations [36, 47]. Furthermore, within the framework of this research, a more comprehensive comprehension of customers' PI for HEMS was pursued. To achieve this, EEH/behaviors were integrated into the combined model, serving as both a predictor and a moderator for customers' PI for HEMS.

The structure of this study comprises six main sections. The second part conducts a literature review of the conceptual model, offering the theoretical framework and hypotheses. In the third section, the research methodology is elaborated, covering data collection methods and measurement tools. Data analysis from the questionnaires and subsequent result discussions are outlined in the fourth section. The fifth section explores the study's implications, focusing on managerial and theoretical aspects. Lastly, the concluding section summarizes the research findings and addresses any encountered challenges and limitations.

Ultimately, our investigation seeks to delve into the following queries among Iranian HEMS customers:

RQ1: Does ATT predict PI?
RQ2: Does SN predict PI?
RQ3: Does PBC predict PI?
RQ4: Does SN predict PN?
RQ5: Does AOC predict PN?
RQ6: Does PN predict PI?
RQ7: Does EEH predict PI?
RQ8: Does EEH predict PBC?
RQ9: Does EEH moderate the association amid ATT and PI?
RQ10: Does EEH moderate the association amid PBC and PI?

2. Literature Review

This study concentrated on identifying determinants that predict the PI for HEMS. We conceptualized the intention to purchase HEMS as a dependent variable influenced by elements of the TPB, specifically ATT, SN, and PBC. Additionally, elements of the NAM, such as AOC, AOR, and PN, were also considered. We integrated EEH/behavior into the model both as a moderator and a predictor for PI. In light of this, we developed a conceptual model, depicted in Figure 1. The model comprises ten hypotheses, all suggesting positive associations between the constructs. The subsequent section delves deeper into these hypotheses and relationships, supported by an extensive literature review.

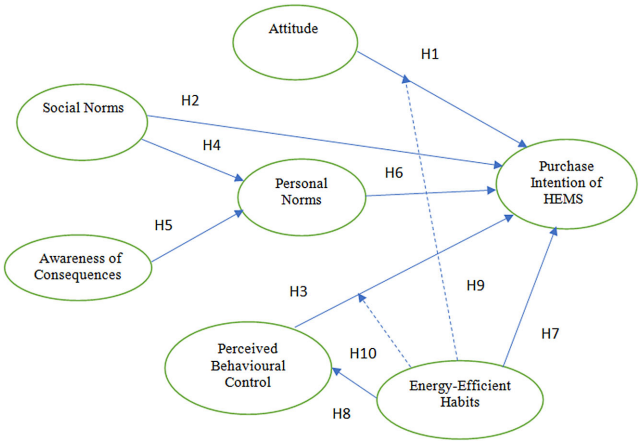
2.1. ATT, SN, and PBC

Key social and individual factors drive the adoption of HEMS and influence customers' PI. These factors include ATTs, SN, and PBC.

According to Ajzen and Fishbein [48], ATTs stem from the evaluation and strength of a belief, suggesting that a positive ATT can motivate individuals to participate in eco-friendly actions at home. They contended that while ATTs might not directly result in behavioral change, they can serve as a predictive or influential factor. Individuals who hold favorable ATTs toward sustainability and ecological conservation are more likely to participate in eco-friendly behaviors. Numerous studies have revealed a positive association amid a positive ATT toward eco-friendly products and the PI regarding them [29, 39, 49]. Moreover, these findings align with research conducted among Iranian consumers [50–52] and within the realm of energy-saving appliances [19, 37]. As we have seen, studies have shown that ATTs can predict GPI, while some studies contradict this [35, 36]. Moreover, so far, no study has examined the impact of ATTs on PI for HEMS among Iranian customers. This gap in understanding is crucial because addressing it could help to enhance Iranian customers' PI for HEMS. Hence, this research seeks to fill the gap by investigating the effect of ATTs on the PI for HEMS among Iranian consumers.

Ajzen and Fishbein [48] expanded the ATT-intention-behavior model to encompass the broader context of SN, emphasizing that people's behaviors significantly influence one another. Due to these SN, consumers tend to adopt eco-friendly behaviors when they perceive that their peers or significant others are doing the same. Thøgersen [53] noted that when SN align closely with personal values, individuals are more inclined to behave in eco-friendly manners. Research has shown that SN significantly influence the decision to invest in energy-efficient technologies [54]. As such, based on evidence from prior studies [21, 40, 55], SN serve as a potent predictor for environmentally responsible behavioral intentions. Moreover, research indicates that social and reference groups, especially peers and close individuals, positively influence consumers' decisions to make eco-friendly purchases [56]. That is, SN play a pivotal role in shaping consumers' GPI [57–59]. This aligns with studies conducted on Iranian consumers [35, 51] and within the realm of energy-saving appliances [19, 21]. A recent investigation into HEMS also underscored that consumers' SN influence their willingness to adopt HEMS [20]. As we have seen, studies have shown that SN can predict GPI, while numerous studies contradict this [29, 36–38]. Moreover, so far, no study has examined the effect of SN on PI for HEMS among Iranian customers. This gap in understanding is crucial because addressing it could help to enhance Iranian customers' PI for HEMS. As such, this research aims to bridge the gap by analyzing the impact of SN on the PI for HEMS among Iranian consumers.

Figure 1
Proposed conceptual model



The third component of TPB, PBC, is understood to offer a motivational foundation for the transition from intention to actual behavior, such as purchasing. As defined by Ajzen and Madden [60], PBC pertains to an individual's assessment of the simplicity or complexity associated with executing a specific behavior. In the context of GPI, it relates to the extent to which people perceive themselves as capable of engaging in environmentally friendly buying behaviors. When individuals perceive themselves as capable of making environmentally friendly choices, they are more likely to indicate an intention to participate in green purchasing behaviors. Several studies have identified a positive association between PBC and GPI [29, 30, 36]. Furthermore, these findings are consistent with research conducted among Iranian consumers [52] and within the domain of energy-saving appliances [19, 28, 37]. However, it is important to note that while some studies support the predictive power of PBC on GPI, others present contradictory findings [38, 39]. Moreover, so far, no study has examined the impact of PBC on PI for HEMS among Iranian customers. This gap in understanding is crucial because addressing it could help to enhance Iranian customers' PI for HEMS. Therefore, this research proposes to address the gap by investigating the impact of PBC on Iranians' PI for HEMS.

Consequently, this study expects that the ATT, SN, and PBC of Iranian consumers will impact their PI regarding HEMS. Building on this assumption, the subsequent hypotheses are posited:

H1: ATT predicts PI.
H2: SN predict PI.
H3: PBC predicts PI.

2.2. AOC and PN

Based on Schwartz [45], the NAM is rooted in three fundamental components: AOC, AOR, and PN. This model delineates how AOC influences the attribution of responsibility, subsequently leading to the formation of PN and observable eco-friendly behavior. de Groot and Steg [61] as well as Schwartz [45] suggest that these relationships serve as the motivational foundation for individuals' environmentally friendly actions. However, the research does not explicitly comprise the AOR component integral to the NAM. AOR stands for people's sense of obligation to engage in a specific behavior [62]. This research contends that this construct can be subsumed under PN. Kantola

et al. [63] contend that the personal responsibility dimension aligns conceptually with moral norms. Given this, the metrics for measuring PN and AOR could be perceived as identical, potentially leading to measurement overlaps. Essentially, this renders the need to view people's AOR as a precursor to their PN redundant.

According to Schwartz [45], AOC pertains to a people's comprehension of the consequences outcomes or ramifications that may arise from their actions. This awareness significantly influences people's perceptions of their ethical obligations, guiding their behavior and ultimately leading to pro-environmental actions. Several studies have indicated that PN are directly influenced by AOC [64, 65]. Additionally, these findings are consistent with research conducted on Iranian consumers across various domains, incorporating eco-friendly products [66, 67] and energy-saving behaviors [68, 69]. However, there is inconsistency in the literature regarding the predictive power of AOC on PN. While some studies support this relationship, others present contradictory findings [40, 41]. Additionally, there has been no investigation into the influence of AOC on the PN of Iranian customers concerning HEMS. Addressing this gap is crucial as it could contribute to enhancing the PN of Iranian HEMS customers. Therefore, this research seeks to address this gap by investigating the influence of AOC on the PN among Iranian HEMS customers.

PN, also referred to as moral norms, represent the internalized sense to either engage in or refrain from certain behaviors [70]. Numerous studies have consistently shown that PN play a substantial role in shaping intentions to adopt eco-friendly behaviors [55, 71, 72]. Individuals who possess stronger PN regarding environmental responsibility are more inclined to express an intention to make green purchases [40, 68, 69]. These results are corroborated by research conducted among Iranian consumers [50] and in the realm of energy-saving appliances [21, 28]. Nonetheless, there is some inconsistency in the literature concerning the predictive power of PN on GPI. While some studies support this relationship, others present contradictory findings [37, 42]. Furthermore, to date, there has been no exploration of the effect of PN on PI among Iranian HEMS customers. This gap in understanding is significant because addressing it could contribute to enhancing Iranian customers' PI for HEMS. Therefore, this research aims to address the gap by investigating the impact of PN on PI among Iranian HEMS customers.

Environmental groups, green movements, and environmentalists represent social norm factors that can inspire consumers to adopt eco-friendly behaviors [40]. In other words, in societies or groups where environmentally friendly behaviors are commonly practiced and valued, individuals are likely to develop stronger PN that favor green purchasing. Thus, widely accepted behaviors and societal expectations regarding environmentally responsible actions could directly inform and shape an individual's personal values and moral perspectives related to green purchasing [34, 40, 68]. Additionally, these results align with research conducted on Iranian consumers [66, 67] and in the fields of energy-efficient behaviors [41]. As we have seen, studies have shown that SN can predict PN in the field of green products, although some research contradicts this [43]. Moreover, to date, no study has examined the impact of SN on the PN of Iranian customers regarding HEMS. This gap in understanding is crucial, as addressing it could help enhance the PN of Iranian HEMS customers. Therefore, this research proposes to address the gap by investigating the impact of SN on the PN of Iranian HEMS customers.

Based on this analysis, it is hypothesized that the PN of Iranian consumers will influence their intention to purchase HEMS. Additionally, it is predicted that both SN and AOC will have an impact on the PN of Iranian HEMS consumers. Consequently, the subsequent hypotheses are proposed:

H4: SN predict PN.
H5: AOC predicts PN.
H6: PN predict PI.

2.3. EEH

EEH refer to the routine practices adopted by individuals that contribute to the conservation of energy. These habits, which include behaviors like using energy-efficient appliances or switching off lights when they're not in use, play a vital role in fostering sustainability [73]. In accordance with prior studies, habits and previous behaviors significantly influence environmentally sustainable behavioral intentions [74, 75]. Chen et al. [20] suggest that people's past experiences and routines related to HEMS systems profoundly shape their ATTs toward green technology and subsequent adoption behaviors. Other research has also highlighted that a habit can affect an individual's PBC [76] and can even act as a moderator between ATT and intention [75].

Consequently, we posit that incorporating energy efficiency habits into the conceptual model can bolster its predictive capacity and offer a clearer understanding of future behavior. As a result, past behavior was incorporated into the integrated model. Considering that most of our survey respondents had no prior experience with HEMS, we sought to substitute the prior use of HEMS with past energy efficiency behaviors. This was done by considering actions like purchasing energy-efficient appliances and light bulbs, as recommended by Chen et al. [20].

To date, there has been a notable absence of studies examining the impact of EEH on PI and PBC of Iranian HEMS customers. Likewise, research exploring the moderating effect of EEH on the association between ATT and PI, as well as between PBC and PI, remains scarce. Bridging these gaps could significantly enhance our comprehension of Iranian HEMS customers' PI and PBC. Therefore, this research seeks to fill these by investigating the effects of EEH on PI and PBC. Additionally, it seeks to investigate the moderating roles of EEH on the associations between ATT, PBC, and PI in the Iranian HEMS customers context. Through this research, we aim to contribute valuable insights into the factors shaping consumer behavior in the context of HEMS adoption in Iran.

Based on the above analysis, we expect that EEH will predict both the PI and PBC of Iranian HEMS customers. Additionally, there is an anticipation that EEH will play a moderating in the associations between ATT and PI, as well as between PBC and PI, among Iranian HEMS customers. Hence, we put forward the following hypotheses:

H7: EEH predict PI.
H8: EEH predict PBC.
H9: EEH moderate the association between ATT and PI.
H10: EEH moderate the association between PBC and PI.

3. Research Methodology

3.1. Data gathering process

A pilot research involving 35 Iranian household residents was conducted prior to the main survey. Feedback from these respondents was gathered and used to make minor modifications

to the format and phrasing of the research. To help participants better grasp the topic of the questionnaire, we included an image illustrating HEMS technology and its application in a smart home. Even though national media and anecdotal evidence indicated that the use of HEMS is gaining traction in Iran, and abundant companies are vying for a greater market share, we added a screening question to the questionnaire. We asked respondents if they planned to use HEMS in the near future. If they answered "yes," they were permitted to complete the remainder of the survey.

Additionally, to meet the target specifications of the study, participants needed to be 18 years or older and affirm that they had previous experience with green technology at home. The pilot study denoted that the proposed questionnaire was reliable, with scores ranging from 0.798 to 0.921. Due to COVID-19, data gathering was conducted through social media channels using self-reported questionnaires, and a random sampling approach was employed.

During marketing research surveys with consumers, researchers may encounter situations where some participants offer responses that diverge from their genuine attitudes, values, or behaviors. Among the different types of response biases, social desirability bias (SDB) stands out as one of the most significant in survey research [77]. Social desirability bias is characterized by respondents' inclination to provide answers that portray themselves positively in the eyes of others [78]. To reduce SDB, we used the following methods in designing the questionnaire: anonymity, accurate wording, setting a specific time and place to fill out the questionnaire, and forced-choice items (5-point Likert scale) [79].

For this study, participants were invited through Instagram and Telegram, as these are the most popular social media platforms in the country. Interested participants were directed to Google Forms, a survey administration tool provided by Google. In total, 261 questionnaires were completed, resulting in an 87% response rate.

3.2. Data measures

After entering the data into SPSS and examining for outliers, 220 questionnaires were considered for analysis. Missing data accounted for less than 3%, with the majority of the missing information pertaining to demographic details. A sample size of 220 participants is deemed acceptable for the research, given the requirement for a significant number of responses.

To mitigate the risk of common method variance (CMV) or common method bias, we randomly altered the order of items in the questionnaire. Furthermore, to assess the potential for CMV, we conducted Harmon's one-factor test. Evidence for CMV exists when most of the covariance is explained by one factor. According to Harmon's one-factor test, it can be said that there is a significant amount of variance or error due to the common method (whether one factor is obtained from factor analysis or several factors are extracted from factor analysis) if one factor among the other factors explains a very large percentage (more than 50%) of the total variance of the variables [80]. In this study, according to this technique, the first factor obtained can explain only 26.417% of the total variance. Since the first factor could not explain much more than 50% of the total variance of the variables, it can be concluded that CMV or common method bias cannot be a major problem.

We employed the structural equation modeling (SEM) methodology, specifically the partial least squares (PLS) approach, utilizing SmartPLS software V3 to examine the hypotheses. The selection of this method is supported by various reasons outlined by researchers. PLS-SEM is proficient in handling research characterized by intricate connections among variables, non-normal distribution, and a limited sample size [81]. Additionally, PLS-SEM excels in managing complex models and advanced analyses, as well as identifying unobserved heterogeneity [82]. Therefore, based on the objectives and characteristics of our study, PLS-SEM was deemed the most suitable analytical approach.

We evaluated the adequacy of our sample size using the inverse-square-root method suggested by Kock and Hadaya [83]. The approach takes into account the likelihood that the ratio of a path coefficient to its standard error exceeds the threshold value of a statistic for a specified significance level. For example, if a path coefficient is 0.2, the significance level is 0.05, and the power level is 0.80, the minimum sample size required is 155. Given our sample size of 220, it surpasses this minimum requirement, indicating adequacy for interpreting the outcomes of the structural model.

The primary instrument for the research was a questionnaire translated into Persian, based on literature relevant to the study's model. The questionnaire comprised 27 items split into two main sections, as outlined in Table 1. The initial section contained 23 items intended to assess the seven constructs of the model. This scale was a reflective, multi-item one utilizing a five-point Likert scale, where 1 represented "completely disagree" and 5 indicated "completely agree." The model for this study was adapted from pro-environmental behavior literature, drawing from works such as Chen et al. [20], Esfandiar et al. [47], Hamzah and Tanwir [36], and Xu et al. [84]. It was necessary to modify the questionnaire items to ensure alignment with the research's aims and the characteristics of the sample group. The questionnaire's second segment was dedicated to demographic attributes and consisted of four items.

To confirm the precision and appropriateness of the Persian version of the questionnaire, we employed the translation-back-translation method, as suggested by Sharifi-Tehrani and Esfandiar [85]. This process helped identify the need for modifications in some items to enhance content accuracy. Subsequently, to verify the clarity and fluency of the translated version and evaluate the internal consistency of the constructs, we tested the questionnaire with a sample of 35 participants. The results indicated that Cronbach's alpha coefficients were larger than 0.7 for all constructs. As per the criterion proposed by Fornell and Larcker [86], this suggests that the questionnaire exhibited reliability, thereby confirming the internal consistency of the research model.

4. Results

4.1. Demographics of respondents

Based on Table 2, of the 220 participants, 45% were male, and 55% were female. The majority, 54.5%, fell within the 18–30 age range. In terms of educational attainment, 30.9% had a diploma, 4.1% had an associate's degree, 36.9% had a bachelor's degree, 26.8% had a master's degree, and 4.1% held a PhD. Regarding monthly income, 20.4% earned less than 20 million rials, 41.4% earned between 20 and 30 million rials, 25.0% earned between 30 and 40 million rials, 9.1% earned between 40 and 50 million rials, and 4.1% earned more than 50 million rials.

The respondents, predominantly women aged 18 to 30, holding either a bachelor's degree or a diploma, and earning an income ranging from 20 to 30 million rials, are perceived as suitable candidates for purchasing HEMS in Iran for several reasons. First, the majority being female suggests potentially higher engagement in eco-friendly product purchasing behaviors [87, 88]. Women

Table 1
Questionnaire items and descriptive statistics

Construct	Items	Mean	SD
ATT	ATT1: Consuming energy-efficient products such as HEMS is valuable.	4.102	0.945
	ATT2: Consuming energy-efficient products such as HEMS is pleasant.		
	ATT3: Consuming energy-efficient products such as HEMS is sensible.		
SN	SN1: If I buy HEMS, most people who are important to me think I should.	3.456	1.331
	SN2: Many individuals who are important to me want me to purchase HEMS.		
	SN3: People whose opinions I value believe that I should invest in HEMS.		
PBC	PBC1: I find it easy to use energy-efficient products such as HEMS.	2.883	1.341
	PBC2: I am confident in my ability to use energy-efficient products such as HEMS.		
	PBC3: I see myself as capable of purchasing energy-efficient products like HEMS.		
	PBC4: I feel that buying energy-efficient products such as HEMS is within my control.		
AOC	AOC1: The balance of nature is delicate and easily upset.	3.578	1.101
	AOC2: To achieve sustainable development, I believe people should live in harmony with nature.		
	AOC3: I am extremely concerned about the world's environment.		
PN	PN1: I feel morally obligated to purchase HEMS.	4.363	1.311
	PN2: I would feel guilty if I did not buy HEMS.		
	PN3: I would be a better person if I purchased HEMS.		
	PN4: When I buy new products, I feel morally obligated to prioritize selecting energy-efficient options such as HEMS.		
EEH	EEH1: I usually purchase energy-efficient light bulbs.	3.563	1.207
	EEH2: I typically purchase energy-efficient household appliances.		
	EEH3: I generally have energy-efficient behaviors such as turning off lights when not needed.		
PI	PI1: I will purchase HEMS in the future.	3.134	1.216
	PI2: I try to purchase HEMS in the future.		
	PI3: I plan to purchase HEMS in the future.		

may be more sensitive to sustainability and energy efficiency issues and thus more aware of their importance. Second, their age range coincides with a period in life where habits and consumption patterns are often formed, making them likely to seek green consumption [89, 90]. Third, their educational background indicates a higher level of awareness and capability in understanding green concepts [42, 87, 91]. These individuals are likely to be seeking more effective solutions for managing energy in their homes. Lastly, with an average income ranging from 20 to 30 million rials, these respondents are likely to be interested in purchasing durable green products [92]. Therefore, these respondents are considered an appropriate target audience for purchasing and utilizing HEMSs in Iran.

4.2. Measurement model results

The primary method utilized to evaluate the adequacy of the measurement model was PLS-SEM, a nonparametric test. The reliability and validity of the measurement model were evaluated using criteria such as composite reliability (CR), Cronbach's alpha for reliability, outer loadings, average variance extracted (AVE) for convergent validity, and heterotrait-monotrait ratio of correlations (HTMT) for discriminant validity. Reliability was evaluated through CR and Cronbach's alpha, with a benchmark threshold set at 0.70. Results indicated that both criteria were satisfied [86]. Convergent validity was assessed through the examination of outer loadings and AVE values, with all items demonstrating loading factors exceeding the required minimum of 0.70. Additionally, AVE values for all constructs surpassed the threshold of 0.50, indicating adequate convergent validity [93]. Table 3 presents a comprehensive overview, demonstrating that all criteria for factor loadings and AVEs were satisfactorily met.

The HTMT was utilized to evaluate discriminant validity, as per Henseler et al. [94] recommendations. Based on Table 4, discriminant validity was affirmed, with all HTMT values falling below the 0.85 threshold.

4.3. Structural model results

The structural model, serving as the second sub-model in PLS-SEM, is employed to assess the model's predictive abilities and the connections among latent variables [93]. Evaluation of the structural model includes analyzing the coefficient of determination (R^2), Stone–Geisser's criterion (Q^2), and path coefficients (T-values).

As depicted in Table 5, the researchers employed the PLS-SEM algorithm along with a bootstrapping procedure to compute the path coefficients. This entailed generating 1000 randomly sampled subsamples through the PLS-SEM algorithm.

The hypotheses were assessed, and as shown in Table 5, the T-values for all hypotheses exceeded 1.96, except for H3: PBC → PI. This confirms the significance of the hypotheses. According to the PLS-SEM results, EEH exert a notably strong positive influence on PI, as evidenced by a standardized path weight of 0.613 ($t = 11.735$). This suggests that EEH are the most influential determinant shaping PI. Considering indirect effects, both SN ($\beta = 0.081$; $p < 0.05$) and AOC ($\beta = 0.054$; $p < 0.05$) exerted an indirect influence positively on PI through PN, with T-values of 2.389 and 2.324, respectively. However, the mediated indirect link from EEH to PI through PBC was not statistically significant ($\beta = 0.008$; $p > 0.05$).

The interaction between EEH and both ATT and PBC was assessed using the product indicator approach [93]. The results reveal that EEH do not moderate the relationships between PBC ($\beta = -0.008$; $p < 0.05$) or ATT ($\beta = 0.010$; $p < 0.05$) and PI. Consequently, hypotheses H9 and H10 were not corroborated.

Table 2
Demographic attributes (n = 220)

Variable	Frequency	Percentage
Sex		
Female	121	55.0
Male	99	45.0
Age		
18 to 30	120	54.5
31 to 40	70	31.8
41 to 50	22	10.1
> 50	8	3.6
Education		
Diploma	68	30.9
Associate	9	4.1
Bachelor	81	36.9
Master	59	26.8
PhD	3	1.3
Monthly income		
Less than 20,000,000 r	45	20.4
20,000,000–30,000,000 r	91	41.4
30,000,000–40,000,000 r	55	25.0
40,000,000–50,000,000 r	20	9.1
More than 50,000,000 r	9	4.1

Note: Rial (r) is Iran's official currency.

To assess the predictive precision of the model, the proportion of variance explained (R^2) was utilized. The R^2 values for PBC, PN, and PI were found to be 0.323, 0.538, and 0.659, respectively. Additionally, the Q^2 value was calculated for additional scrutiny of the model's predictive significance. This was accomplished through a blindfolding procedure in PLS-SEM. Based on Chin [95], if Q^2 values exceed zero, the model demonstrates satisfactory predictive relevance. In light of the findings of this research, Q^2 values for PBC (0.263), PN (0.337), and PI (0.513) all exceeded this threshold. As advised by Henseler et al. [94], this validates the predictive importance of the endogenous variables in the ongoing inquiry.

4.4. Sobel test

For a more comprehensive analysis, we used the Sobel test as it enables the determination of a full mediation relationship among the research variables [96]. As per Sobel's [97] guidelines, a Z-value exceeding 1.96 confirms the significance of a variable's mediating effect. Based on Table 6, the Sobel test outcomes concerning mediating association among the constructs are delineated. Please consult Table 6 for additional information.

4.5. Variance accounted for (VAF) test

For a more in-depth analysis, we employed the VAF test. This test enables us to identify a partial mediation relationship among the research variables [96]. Based on Hair et al. [93], VAF is a statistical tool used to evaluate the effectiveness of a regression model. It calculates the percentage of total variation in the observed values that can be accounted for by the variation in the predicted values. The VAF value, ranging from 0 to 1, indicates the magnitude of the influence exerted by the mediating variable, with values closer to 1 indicating a stronger influence. The findings of the VAF test, illustrating the mediation relationships among the variables, can be found in Table 7. For further information, please consult Table 7.

5. Discussion

The study empirically examined the proposed conceptual framework to understand the influence of several factors on Iranian consumers' intentions to purchase HEMS, including ATT, SN, PBC, AOC, PN, and EEH. Additionally, the study examined the moderating effect of EEH on the association among PI, ATT, and PBC.

This research investigated the influencing factors of PI among Iranian consumers of HEMS by developing an integrated structural model. Overall, the components of the research model significantly affected PI, explaining 65.9% of the variance in the dependent variable, which is the behavior of purchasing intention. Among the variables in the research model, all factors (such as ATT, SN, AOC, PN, and EEH) significantly predicted PI, except for PBC.

More specifically, results from the PLS-SEM analysis indicated that consumers' norms exert a positive influence on their PI (H2, $\beta = 0.114$, $p < 0.05$). This suggests that consumers heavily weigh the opinions of significant individuals in their lives (like family, friends, colleagues, and peers) when considering a HEMS purchase. This observation aligns with Hofstede's classification of national cultures: SN typically have a pronounced impact in collectivist nations, a category that includes Middle Eastern countries such as Iran, the focus of this study [98]. Similarly, a notable positive relationship was observed between PN and PI. This underscores the proposed function of PN as a significant forecaster for PI amid HEMS Iranian consumers (H4, $\beta = 0.160$, $p < 0.05$). This underscores the importance of incorporating both personal and SN in models that explore environmentally responsible behavior, a stance echoed by prior research [47, 55]. Interestingly, compared to SN, PN exhibited a more pronounced influence on PI. This aligns with earlier research suggesting that PN are the primary drivers of pro-environmental actions [72, 99].

The results from the PLS-SEM demonstrated consumers' EEH positively influence both their PBC (H7, $\beta = 0.568$, $p < 0.001$) and PI (H8, $\beta = 0.613$, $p < 0.001$). Yet, the effect of EEH as a moderator wasn't significant. As seen in Table 5, the path between ATT and PI was the most tenuous in the model, while the connection between EEH and PI was the most robust (H8, $\beta = 0.613$, $p < 0.001$). This underscores the importance of habits as a crucial predictor PI for HEMS. Such findings suggest that entrenched consumption patterns and habits might deter individuals from adopting sustainable behaviors, a sentiment echoed in earlier studies [21].

The outcomes of the research emphasize the impact of both SN and AOC on individuals' PN, ultimately affecting their intention to purchase. The substantial R^2 values associated with PN (0.538) highlight the significance of the NAM in predicting environmentally sustainable behavior. This suggests that consumers place considerable importance on moral or PN when making decisions regarding HEMS. These results align with previous studies carried out in the Iranian setting, in which SN [35, 51], PN [50], and AOC [67] have been identified as crucial drivers of consumers' GPI.

The PLS-SEM results indicated that PBC doesn't significantly shape the PI of Iranian HEMS consumers (H3). This aligns with findings from Asif et al. [51]. One possible explanation is that HEMS represents a novel technological product. As Chen et al. [20] highlighted, many users are currently reluctant to transition to

Table 3
Measurement items, reliability, and convergent validity

Construct	Items	Factor loadings	α	CR	AVE
ATT	ATT1	0.879	0.819	0.891	0.734
	ATT2	0.928			
	ATT3	0.755			
SN	SN1	0.798	0.795	0.880	0.711
	SN2	0.898			
	SN3	0.831			
PBC	PBC1	0.924	0.921	0.950	0.864
	PBC2	0.941			
	PBC3	0.923			
AOC	AOC1	0.901	0.866	0.918	0.789
	AOC2	0.908			
	AOC3	0.855			
PN	PN1	0.793	0.831	0.888	0.666
	PN2	0.746			
	PN3	0.808			
	PN4	0.908			
EEH	EEH1	0.927	0.940	0.961	0.893
	EEH2	0.956			
	EEH3	0.951			
PI	PI1	0.902	0.895	0.935	0.827
	PI2	0.921			
	PI3	0.905			

Table 4
Discriminant validity

	ATT	AOC	EEH	PBC	PN	PI	SN
ATT	0.47						
AOC	0.31	0.51					
EEH	0.39	0.37	0.61				
PBC	0.39	0.68	0.71	0.71			
PN	0.38	0.47	0.78	0.59	0.73		
PI	0.46	0.57	0.56	0.77	0.82	0.64	
SN	0.45	0.54	0.53	0.76	0.80	0.62	0.63

Table 5
Path coefficients and hypotheses testing

Hypotheses	β	T
H1. ATT → PI	0.079*	2.412
H2. SN → PI	0.114*	2.515
H3. PBC → PI	0.015^{ns}	0.284
H4. SN → PN	0.509***	11.094
H5. AOC → PN	0.341***	7.464
H6. PN → PI	0.160*	2.444
H7. EEH PBC	0.568***	13.718
H8. EEH → PI	0.613***	11.735
H9. ATT * EEH → PI	0.010^{ns}	0.277
H10. PBC * EEH → PI	-0.008^{ns}	0.272

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, ns = no significant

Table 6
Sobel test

Path	a	b	Sa	Sb	Z
AOC→PN→PI	0.341	0.160	0.058	0.045	3.042**

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, ns = no significant

such systems. Thus, while this study's results suggest that Iranian consumers don't see a direct link between PBC and their intent to purchase HEMS, it's important not to diminish the potential significance of PBC in influencing intentions regarding HEMS technology in the broader context.

5.1. Theoretical implications

The theoretical ramifications of this research are extensive. Initially, it adds to the expanding corpus of literature regarding individuals' intentions to purchase HEMS. While previous studies have explored various factors influencing consumers' green purchase behaviors, there has been limited research specifically addressing HEMS. By drawing on the TPB and NAM, this research explores the factors influencing individuals' intentions to invest in HEMS in Iran. Significantly, the findings highlight the importance of factors such as ATT, SN, AOC, PN, and EEH in shaping household residents' PI toward HEMS. Moreover, this research extends existing

Table 7
VAF test

Path	a	b	c	VAF	Results
SN → PI, SN → PN → PI	0.509	0.160	0.114	0.41	About 41% of the overall impact of SN on PI is indirectly clarified by PN.
EEH → PI, EEH → PBC → PI	0.568	0.015	0.613	0.01	Around 1% of the total influence of EEH on PI is indirectly elucidated by PBC.

literature by proposing EEH as potential influencers on the impacts of PBC and ATT on PI in the HEMS context.

5.2. Practical implications

This research provides various practical insights. The findings suggest that consumers are progressively cognizant of ecological issues and the importance of energy conservation. Consequently, normative beliefs shape Iranian consumers' SN, suggesting societal expectations for them to adopt pro-environmental behaviors. Given this, Iran appears to be a promising market for eco-friendly products. To remain competitive in today's marketplace, it is imperative for Iranian companies to adapt and address emerging societal concerns [4]. As such, marketers and businesses should highlight the eco-friendly and cost-saving attributes of their products in advertising and promotional activities. For instance, they can disseminate information on eco-labels, the ecological benefits of their products, and the broader advantages of sustainable consumption through social media and other digital platforms. This approach can enhance consumers' comprehension and awareness of environmental issues, motivating them to install HEMS in their homes. Given that consumers are driven by ethical considerations to invest in HEMS, businesses can bolster their HEMS offerings by bolstering their commitment to social responsibility. In their marketing communications, marketers should address consumers' moral duty to the environment, emphasizing the environmental advantages of using HEMS. Additionally, marketers and businesses should highlight the ramifications of environmental degradation to remind consumers of their environmental responsibilities and inspire them to opt for HEMS. Such efforts can be amplified on social media platforms through strategies like online reviews and influencer partnerships.

6. Conclusion

This study sought to analyze the PI of Iranian consumers regarding HEMS. We explored the influence of factors such as ATT, SN, PBC, AOC, PN, and EEH on their inclination to invest in HEMS.

This research has significantly contributed to bridging the research gap regarding the purchase behaviors of Iranian consumers in relation to HEMS. Our findings reveal that the ATT and SN of Iranians are crucial determinants that forecast their PI regarding HEMS. Notably, there is a direct correlation between Iranians' SN and their PN. Moreover, their AOC is a predictor of their PN concerning environmental responsibility. Additionally, while the PN of Iranians are influential in shaping their PI for HEMS, their EEH also play a vital role in predicting both their PI and PBC. Finally, the mediation analysis revealed that AOC influences PI through PN. Moreover, PN indirectly account for approximately 41% of the total effect of SN on PI. These insights are pivotal, highlighting the uniqueness of Iranian consumers and emphasizing the need for tailored strategies for promoting HEMS in the Iranian market.

Despite its valuable findings, there are various constraints to consider in this study. First, given its focus on Iran, its applicability to other countries might be limited. Second, there are only a few published studies that focus on consumers' intentions to purchase HEMS. Lastly, this study relied on intentions as a surrogate for actual behavior. While using intentions as a proxy is standard practice in cross-sectional design studies, it doesn't always translate into real-world behavior. To bridge the intention-behavior gap, future research might consider employing mixed methods, observational studies, and longitudinal approaches [67].

Considering the constraints highlighted in this study, future research could delve into several avenues. First, it would be advantageous to investigate this matter across various countries. Given that our data was sourced from a specific nation, the findings might not be universally applicable, especially in contexts distinct from Iran, such as Western nations. Therefore, we advise that our research model be applied with prudence in different cultural settings. Additionally, there's a pressing need for more in-depth studies on consumers' purchasing intentions regarding HEMS. Given that demographic attributes such as age, sex, educational attainment, etc., may influence consumer decision-making processes, it is important for future research to explore how these factors moderate the relationships identified in our research.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Maryam Zidehsaraei: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Minoo Zidehsaraei:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Visualization.

Kourosh Esfandiar: Conceptualization, Validation, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing.

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