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Antecedents of energy consumption intention to usage by home energy management system: a case study of Galicia's homes in Spain

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Abstract. The residential sector is a substantial consumer of energy in Spain. A new electricity tariff was applied in Spain to make home consumers manage their energy consumption based on the variation of electricity price during the day, which contributes to energy security, increases the penetration of Renewable Energy Sources (RES) into the grid, maintains grid stability, and reduce CO_2 emissions. To ensure the successful implementation of the new Demand Response (DR) program, it is necessary to investigate the factors that might affect home energy consumers to use the Home Energy Management System (HEMS). This work aims to examine the factors that affect the Spanish home energy consumers' acceptance to participate in DR, which have not been studied yet after the new electricity tariff. In addition, highlighting the role of economic benefits and environmental awareness factors in the acceptance of participating in DR using HEMS. The Technology Acceptance Model (TAM) is used in this work with four independent factors, attitude toward use as a mediating effect, and one dependent variable of intention to use, then hypotheses were set for each. The selected research method was a diagnostic survey technique through a standardized survey questionnaire distributed in person and online, that Galicia, Northwest Spain was taken as a case study. In terms of the statistical results of Probability value (P-value) and Critical Ratio (C.R.), it was found that the family's economic benefits and environmental awareness affect the attitude toward using HEMS after the new electricity tariff in Spain and attitude toward using HEMS has a significant impact on the intention to use HEMS. However, the usefulness and ease of using HEMS for managing energy consumption do not influence the consumers' attitudes toward adopting HEMS. The direct effect of usefulness on the intention of using HEMS is higher than the indirect effect through attitude. Thus, the mediating effect of the attitude to the relationships between usefulness and intention to use is not significant. The results help the Spanish policymakers to draw up policies to effectively disseminate strategies to encourage home consumers to contribute to energy security and assist energy management researchers in incorporating key factors that impact energy consumers into their proposed models. By doing so, these models can clarify the financial and environmental advantages of effective energy consumption management, thereby encouraging energy consumers to adopt more sustainable practices.

Keywords: Demand response / energy management / technology acceptance model / electricity tariff

1 Introduction

The world's population increased by 51.33% between 1990 and 2023 [1]. The population growth concurrent with rapid technological advancement drove up energy demand; energy consumption per capita increased in the world by about 64%, while 73% in Spain in the residential sector gradually from 1985 to 2020 [2]. This increase in energy consumption has negative effects on energy security and the environment [3]. Recently, the risk of energy security, which is related to the blackout of the main grid, increased due to the high energy demand, especially in peak periods. Many recent power outages have occurred in different parts of the world. The California power crisis in 2020 raised interest in the risk of the shortage of local energy resources to cover the energy demand and power outages during peak periods [4]. In the last cold winter season in China, the

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power plants could not meet the energy demand, not even keeping lights on during peak periods [5]. The biggest blackouts in India were on the 30 and 31 of July 2012, affecting about 670 million people due to high energy demand [6]. The power blackout has impacts in many aspects, 1) direct economic impact 2) indirect economic impact 3) social impact [7]. Obviously, it's a global problem and has a strong relationship to energy consumption behavior.

Spain has grown in sharing renewable energy sources (RES) in electricity generation. The percentage of sharing RES in 2016 was 38.6%, and in 2022 it became about 42% [8,9]. Though the world is moving to renewable energy, the electrical grid's stability continues to face challenges arising from the fluctuations of renewable power generation caused by changing weather conditions and the varying energy demand throughout the day. As well, a reliable supplier that covers the growth of energy demand in the future is necessary, as integrating more RES into the grid is difficult without energy consumers' response to the grid status and adjusting their energy consumption [10,11]. In this context, it's worth noting that the residential sector plays a key role in the energy market, where it consumes 19% of the total energy consumption in Spain [12]. Therefore, making household energy consumers part of the energy system, raising awareness about their roles, and the need to be responsible consumers regarding saving energy could be a part of the solution to the above-mentioned problems, which help in enhancing energy security and improving the RES sector development.

On the other hand, even though the electricity generation mix is relatively diversified, Spain is not endowed with significant fossil fuel reserves; it's the fourth-largest European country in energy consumption, with no local production of oil and natural gas [13]. For example, in 2022 Spain imported natural gas by about 446 terawatt-hours from different countries [14]. Therefore, it is necessary to plan for the future energy security.

Smart Grid (SG) technology allows the end-user to participate in the decision-making of the electricity system based on the information exchange between the consumers and the main grid, which helps in the security and reliability of the grid and efficient energy usage. Home Energy Management System (HEMS) can contribute to energy security by reducing energy consumption in peak periods, using local RES such as Photovoltaic (PV), and shifting the operation time of household appliances to the high PV-power generation and grid's low price periods [15,16]. Therefore, HEMS helps in reducing the use of auxiliary generators to meet the energy demand, enhancing the grid's stability, reducing the amount of fuel imported from outside, and reducing CO_2 emissions.

Spain put in place a plan to install smart meters for energy consumers and referring to the energy policy review report of Spain done by the International Energy Agency (IEA), 99.64% of the traditional meters were replaced by smart meters by late 2019 [17]. Many demands response (DR) programs based on SG were applied in Europe lately, to make customers use energy efficiently based on the grid generation and demand status [18]. In Spain, the current electricity tariff which has been applied in 2021 contains three periods (low, medium, and high), whereas the electricity price change hourly [19]. However, participation in DR in Spain is still low [20]. The main barriers affecting using HEMS are the consumer's dissatisfaction with participating in DR programs or unaware of DR benefits, in addition to the absence of policy frameworks in support of participation in DR [21]. Therefore, policymakers must consider consumer satisfaction and raise awareness of the importance of sharing in HEMS based on DR programs, even for consumers who have not yet engaged.

The Technology Acceptance Model (TAM) is one of the most influential theories of technology acceptance that models the causal relationships of internal belief-attitude-intention-actual behavior by two main factors, Perceived Usefulness (PU), and Ease of Use (PE) [22]. PU and PE factors play a fundamental role in shaping the user's Attitude towards (ATT) adopting technology, which, in turn, influences their Intention to Use (INT) [22]. Recently, TAM is used to study consumers' acceptance of new energy technologies [23–30]. However, few studies have examined the relationship between economic benefits, environmental awareness, ease of use, usefulness, and attitude in consumers' acceptance model of adopting SG and HEMS. Moreover, no research on Spanish consumers' acceptance of participation in DR and adopting HEMS has yet been carried out after the new electricity tariff in Spain, to understand the factors that might affect their acceptance.

The objectives of this work are to investigate the factors influencing the intention of Spanish household energy consumers, to participate in DR after the new electricity prices by managing their home energy consumption efficiently. In addition, helping the policymakers to establish successful policies that enhance the adoption of HEMS and participation in DR by identifying the acceptance factors of HEMS. To accomplish that, we proposed an extended TAM by adding consumers' environmental Perceived Awareness (PW), and Family's Economic Benefits (FEB) factors to TAM, and measuring the mediating effect of attitude between usefulness and intention to adopt HEMS.

2 Materials and methods

To achieve the objectives of this work, some factors that might affect consumers to participate in DR were selected based on a systematic review. After that, TAM theory was used to implement the research model. Then, several hypotheses were proposed, based on a systematic review, to gain a deep understanding of Spanish household energy consumers' attitudes about the possibility of participating in DR programs after the new electricity tariff. A sample case study was selected to carry out the research and extract results, where AMOS 20.0 was used for analyzing the collected data.

2.1 Conceptual model

The present study uses TAM to investigate the factors that might affect consumers' acceptance of participating in DR after the new electricity tariff. Two factors were added to

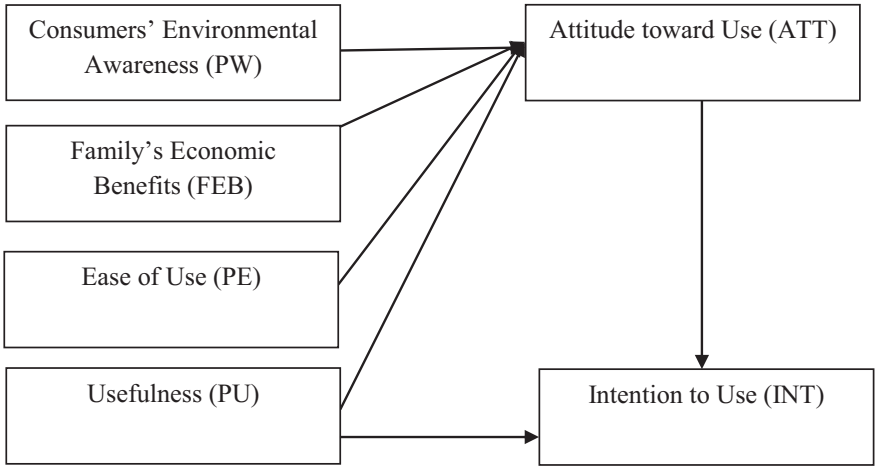

Fig. 1. The conceptual model.

the TAM-based model as shown in Figure 1. The developed TAM research model consists of four exogenous variables (Consumers' Environmental Awareness, Family's Economic Benefits, Ease of Use, and Usefulness), and mediating effect (Attitude toward Use), and one endogenous variable (Intention to Use).

2.2 Hypothesis development

In the proposed model, perceived usefulness is expressed that managing energy consumption by engaging in a DR strategy is beneficial. According to David [22], the relationship between intention to use and perceived usefulness is direct. Many studies showed that perceived usefulness has a positive effect on the intention to use [26,31–33]. Attitude toward use is defined as the degree of how the user feels about using HEMS after applying the new electricity tariff, whether positive or negative feelings. According to TAM theory [22], the author contended that the user's intention to use new technology is affected by his attitude toward using it, which was also confirmed by several studies [25,26,34,35]. The perceived ease of use is a metric of satisfaction in adopting HEMS by easily participating in DR, monitoring smart meters, and turning on/off home appliances free of physical and mental effort. Many studies found that the higher ease of use and usefulness of use HEMS have a positive effect on attitudes toward using HEMS [26,36,37]. Moreover, if the direct effect of a variable on another variable is more than the indirect effect through a mediator, this indicates that the mediator has no influence [26,38,39].

The perceived consumers' environmental awareness variable is the perceived awareness that participation in the DR strategy help preserves the environment. Environmental awareness has become an important factor in human behavior; it refers to the knowledge and concern about the impact of human behavior on the climate and environment [40]. Whereas preserve the environment is one of the main goals of DR by decreasing the use of fossil fuels and increasing the integration of RES. A previous study demonstrated that a high level of environmental awareness helps to make conscious choices for acting in an environmentally friendly way [41]. A survey done in the UK indicated that the majority of respondents were accustomed decrease the use of electricity and gas due to their effect on the environment, and climate change [42]. A study was performed on the factors that affect consumers' purchasing intention to buy energy-efficient products, the results showed that the energy and environmental awareness of the consumers' have a significant impact on consumers' attitudes toward purchasing energy-efficient products [34]. Factors that affect purchasing energy-saving appliances were studied, and it was found that environmental awareness has a positive effect on attitude [43]. A case study done on Japanese home consumers indicated that environmental awareness positively influences the adoption of DR [44]. According to Alkawsi and Baashar (2020), it found that environmental awareness of using smart meters positively influences consumers' attitudes toward using smart meters. [45]. A survey carried out in Poland highlights the importance of energy consumers place on using RES and saving energy as means of preserving the environment [46]. The family's perceived economic benefits are about understanding and implementing the basic concept of economics and how families behave and make economic decisions, where economic benefits play a role as a behavior essential to achieving individual well-being [47]. The perceived family's economic benefits variable is the perception of economic benefit to be gained by participation in the DR strategy. For the attitude toward adopting technologies, the economic incentives and benefits are strong motives for accepting new technologies [48,49]. HEMS based on the DR programs can help to decrease the electricity cost by 23% [50]. Moreover, it is found that consumers' attitudes in managing their energy consumption and saving energy contribute to the country's economic growth, which will reflect positively on them [51]. A study evidenced that reducing the electricity bill affect strongly consumers' attitudes in saving energy at home [52]. Another study undertaken in Finland aimed to examine the consumers' energy consumption behavior and their intention to adopt

HEMS. The results revealed that consumers are willing to adjust their consumption in return for financial and environmental benefits [53].It was found that environmental awareness and economic indicators are important to consider for the sustainability measurement of the renewable energy sector [54]. Regarding that, the following hypotheses were set:

H1: Attitude has a positive impact on the intention to use.

H2: Perceived usefulness has a positive impact on the intention to use.

H3: Perceived consumers' environmental awareness has a positive impact on attitude.

H4: Perceived family economic benefit has a positive impact on attitude.

H5: Perceived ease of use has a positive impact on attitude.

H6: Perceived usefulness has a positive impact on attitude.

H7: Attitude toward mediates the relationship between perceived usefulness and intention to use.

2.3 Data collection and analysis

The study focused on household energy consumer sampling in Galicia, Northwest Spain; 150 questionnaires were distributed by hand and online to consumers. Twenty questionnaires was not received, and ten questionnaires were incomplete (missing) answers.

The survey was done on homeowners in Galicia provinces, Northwest Spain; with seven-point Likert scales for measuring all variables. However, the data set of 120 samples was encrypted and saved in SPSS version 19.0 and analyzed using AMOS 20.0. Hence, 120 answers were used in the post-analysis, where the response rate was 80%.

3 Results

3.1 Profile of the respondents

The study encompassed a total of 120 participants, comprising 61 men and 59 women, all of whom were over 18 yr old. The demographic variables in the study's sample consists of the following elements: (1) Gender, (2) Age, (3) Marital status, (4) Type of residence, (5) Type of home, (6) Year home built, (7) Members of the family, (8) Province of the residence, (9) Number of inhabitants of the locality, (10) Education level, (11) Salary. Table 1 shows the demographic characteristics of the collected data.

The data clearly indicates that a significant portion of the surveyed individuals fell within the age range of 19–30 yr, accounting for 36.7% of the sample. In terms of marital status, an overwhelming majority, specifically 58.3% of respondents, reported being single. When examining the housing situation, 55% of respondents identified as homeowners, while the remaining 45% were renters. Furthermore, the predominant type of residence was apartment buildings, making up 62.5% of the housing choices among respondents. Additionally, it's worth noting that nearly 39.22% of the homes surveyed were constructed before the year 1990.

Among the surveyed family members, a significant portion, comprising 54.2%, consisted of households with 3-4 individuals. Notably, the majority of respondents hailed from A Coruña, making up 65.8% of the total sample. In terms of the population size of their respective localities, nearly half of the respondents, specifically 47.5%, resided in areas with a population exceeding 50,000 inhabitants. Regarding educational attainment, a substantial 45.8% of respondents had pursued higher studies. Lastly, when it came to the income levels of the participants, a notable 35.8% reported earning a monthly salary falling within the 1000-2000&z.euro; range.

3.2 Descriptive statistics of variables

As depicted in Table 2, the average score for consumers' perceived environmental awareness is quite high, standing at 5.3. On the other hand, the ease of use, with an average score of 3.66, appears relatively lower. This suggests that when considering the intention to use, there is a clear need to place more emphasis on enhancing the ease of use aspect for consumers.

3.3 Reliability test

Composite reliability (CR) is used to test reliability in Structural Equation Modeling (SEM) analysis [55,56]. According to many studies, the CR scale should be greater than 0.60, or greater than 0.70 [57,58]. In addition, CR exceeding 0.70 has been said to reveal a satisfactory internal consistency [56,59]. In this study, the CR test, as illustrated in Table 2, was done. The results revealed that all variables within the final structure of the study attained CR values exceeding 0.70. This observation underscores the fact that all constructs demonstrate a commendable level of internal consistency, aligning with established criteria [56,57,59,60].

3.4 Confirmatory factor analysis

SEM is used to test the study's research model and hypotheses, while Confirmatory Factor Analysis (CFA) is used to verify the factor structure of a set of observed variables [39,61]. In this work, the chosen criteria for testing the suitability of fit for the generation model are the chi-square (X^2), P-value, degrees of freedom (DF), Goodness of-fit-Index (GFI), Adjusted GFI (AGFI), Incremental Fit Index (IFI), Normed Fit Index (NFI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). Figure 2 shows the results of the structural equation model, it is found that X^2 has a value of 81.004 with a DF of 53. Where the GFI is 0.974, AGFI is 0.955, IFI is 0.990, NFI is 0.970, CFI 0.989, RMSEA is 0.034, and X^2 / DF of 1.528<3. The results underscore the appropriateness and acceptability of the

Table 1. Demographic characteristics of respondents.

Demographic characteristics		Frequency	Percentage (%)
Gender	Male	61	50.8
	Female	59	49.2
Age	18–30	44	36.7
	30–42	24	20
	42–54	33	27.5
	54–66	17	14.2
	More than 66	2	1.7
Marital status	Single	70	58.3
	Married	41	34.2
	Divorced	6	5
	Widowed	3	2.5
Type of residence	Owner	66	55
	Renter	54	45
Type of Home	Independent Single-family home	33	27.5
	Semi-detached or semi-Detached house	10	8.3
	Apartment building	75	62.5
	Other	2	1.7
Year home built	Before 1991	47	39.2
	1991–2001	35	29.2
	2002–2012	34	28.3
	After 2012	4	3.3
Members of the family	1–2	42	35
	3–4	65	54.2
	5–6	11	9.2
	More than 6	2	1.7
Province of the residence	A Coruña	79	65.8
	Lugo	8	6.7
	Ourense	9	7.5
	Pontevedra	19	15.8
	Outside of Galicia	5	4.2
Number of inhabitants of the locality	More than 50,000	59	47.5
	10,000 − 50,000	35	29.3
	Less than 10,000	28	23.3
Education level	Primary studies / no studies	3	2.5
	Secondary studies (baccalaureate / FP)	28	23.3
	Higher studies (University / Higher FP)	55	45.8
	Doctorate	34	28.3
Salary (per month)	Less than 1000 €	29	24.2
	1000–2000 €	43	35.8
	2000–3000 €	19	15.8
	More than 3000 €	21	17.5
	None	8	6.7

Table 2. Descriptive statistics of constructs.

Construct	Original items	Total mean	Items after CFA	Composite reliability
PW	5	5.30	2	0.87
FEB	5	4.31	3	0.80
PE	5	3.66	2	0.74
PU	5	4.34	2	0.88
ATT	5	4.51	2	0.78
INT	4	4.57	2	0.83

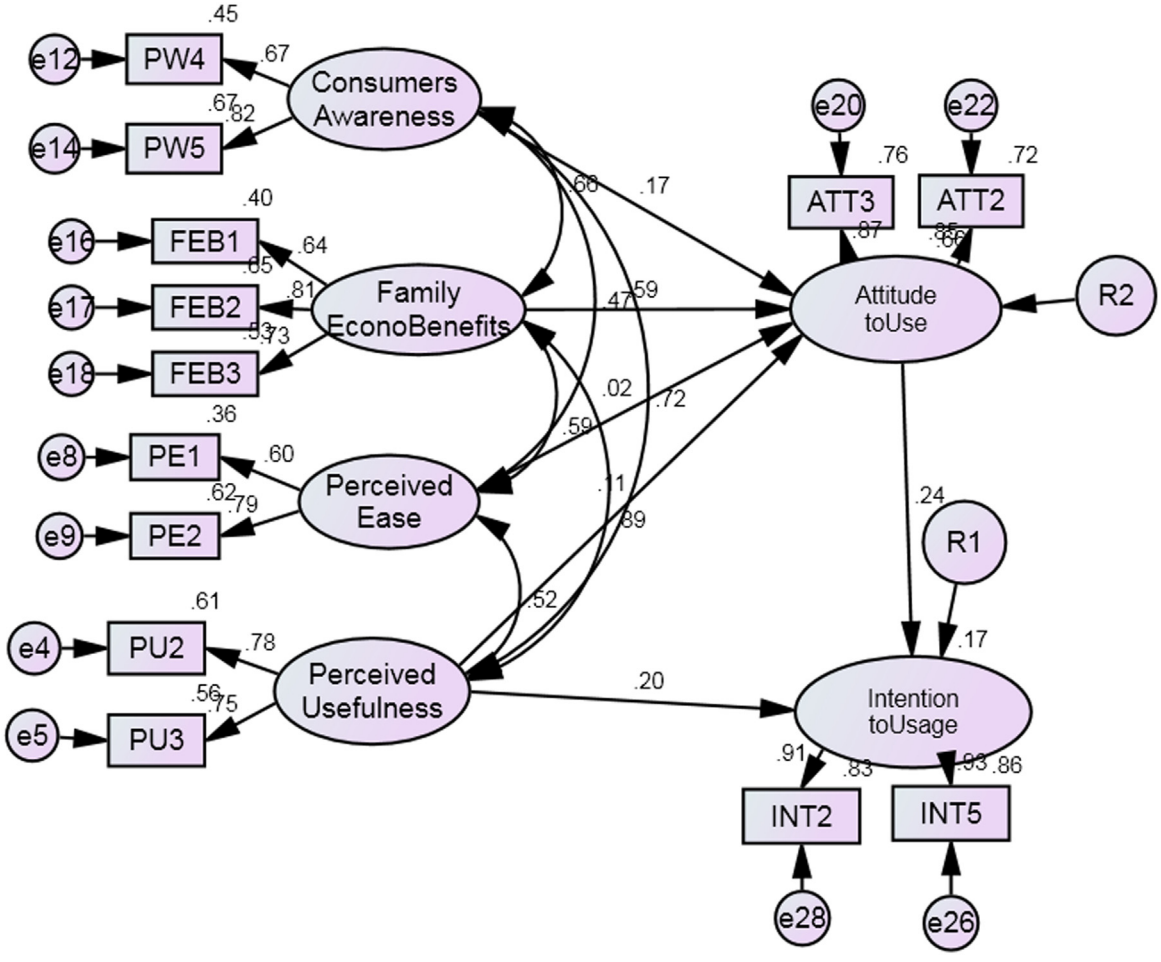

Fig. 2. Results of the structural equation model.

model generation, as they align with the recommended threshold values [61]. Therefore, it can be concluded that all factors are validated and acceptable.

3.5 Hypothesis test

The hypotheses were tested using a Path Analysis, with acceptance or rejection decisions were made using the P-Value based on the Critical Ratio (C.R.) [62]. The direct relationship represents a direct effect through the independent (external) construct on the dependent (internal) construct. Table 3 presents the results of the estimation of the weight of the regression, the standard error (SE) of the weight of the regression, and the C.R of the weight of the regression.

The results indicated the acceptance of hypotheses H1, H2, H3, and H4, while hypotheses H5 and H6 were found to be rejected. Additionally, an examination was conducted to assess the role of the mediator, specifically the influence of attitude toward use, in mediating the relationship between perceived usefulness and intention to use. Many studies indicated if the direct effect is greater than the

Table 3. Results of the hypotheses.

H.	From	To	Estimate	SE	C.R.	*P*-Value	Acceptance
H1	ATT	INT	0.321	0.134	2.393	0.001	YES
H2	PU	INT	0.259	0.131	1.971	0.049	YES
H3	PW	ATT	0.174	0.085	2.047	0.041	YES
H4	FEB	ATT	0.562	0.175	3.215	0.001	YES
H5	PE	ATT	0.016	0.066	0.243	0.808	NO
H6	PU	ATT	0.104	0.188	0.557	0.577	NO

indirect effect, this confirms that the mediator has no influence [38,39]. Thus, attitude toward use does not affect the relationship between perceived usefulness and intention to use, where the direct influence was 0.197, and the indirect effect was 0.025.

4 Discussion

The main objective of this study is to identify factors affecting consumers' participation in DR; by managing their energy consumption in response to the electricity price after the new tariff in Spain. The findings show that PU has a significant effect on the intention to adopt HEMS after the new electricity tariff. This means that the favorable or unfavorable intention to adopt HEMS is to the degree to which the person believes HEMS would improve the quality of life and makes consumers take part in contributing to energy security. The results are consistent with prior studies that underscored the positive impact of usefulness on the intention to use new technology [26–28,35]. However, when it comes to PU and PE, this research found that they have no influence on the consumers' attitudes toward adopting HEMS. This indicates that the perceived ease of turning on/off the appliances and the usefulness of managing energy consumption in response to electricity prices are not directly affecting consumers' attitudes. This finding aligns with prior studies on the acceptance of new technology [63–65].

The results show a positive effect of consumers' environmental awareness and family's economic benefits on attitude. This indicates that the higher awareness and family's economic benefits, the more participation in HEMS and the more contribution to energy security. The results are supported by previous research findings [28,66–69]. Accordingly, the effect of perceived environmental awareness and economic benefits on consumers' attitudes are important factors to take into consideration, when suggesting energy policies for adopting HEMS in line with the development of the energy sector; where consumers' attitudes will influence their intention to use HMES as a means to manage energy consumption.

The mediation results reveal that attitude does not mediate the effect between perceived usefulness and intention to use HEMS. This can be attributed to the fact that the consumers consider the perceived usefulness of using HEMS relatively important. Based on the results, attitude has a significant influence on the intention to use HEMS, which is supported by previous studies [26,27,36,70]. It can be argued that Spanish consumers' attitude towards using HEMS is positive owing to the environmental awareness and perceived family's economic benefits of participating in DR and managing energy consumption at home.

Thus, policymakers ought to place a focus on these factors through offering financial incentives, encouraging the installation of local renewable energy systems at home, and reducing taxes on saving-energy appliances. And clarify the benefits of managing energy consumption according to the new electricity prices on the future economic and environmental trajectory of Spain. Furthermore, efforts should be directed towards enhancing consumer awareness regarding the risks associated with fossil fuel usage, the advantages of using RES, and the importance of using HEMS on preserving the environment and enhancing energy security. These endeavors can be facilitated through various channels such as social media, informative articles, the inclusion of relevant content in university curricula, and the organization of scientific symposiums and seminars.

5 Conclusion

An extended model of TAM was proposed to investigate the factors that might affect the intention to use HEMS and participate in demand response after the new electricity tariff in Spain. Based on the literature review, the perceived customer's environmental awareness and family's economic benefits were added to the TAM model. The study was done in Galicia, Northwest Spain. After gathering the data, it underwent analysis using Amos 20. The data analysis results fulfilled the research objectives, providing valuable insights into the influence of each factor on the intention to use HEMS.

The study elucidated the impact that various factors exert on shaping the attitude toward and intention to use HEMS. The results show a positive impact of the consumers' environmental awareness and family's economic benefits on the attitude toward using HEMS. In addition, the results show a direct positive effect of usefulness and attitude toward use on the intention to use HEMS. It is worth noting that the higher the economic benefits and environmental awareness, the more attitude to use HEMS, which in turn leads to formulating positive intention to use HEMS. The perceived family's economic benefit (C.R.=

3.215) stands out as the most important factor in improving consumer acceptance, which is consistent with the function of HEMS; saving energy and consuming energy in the low-price periods reduces the bill. Likewise, the influence of environmental awareness (C.R. = 2.047) on the attitude towards using HEMS holds notable significance.

In other words, energy consumers are willing to manage their energy consumption to preserve the environment. This willingness is contingent upon them gaining adequate awareness of climate change issues and realizing their essential role in participating in DR aimed at environmental enhancement. Besides, the results reveal that usefulness has a positive and direct impact on intention to use, and the attitude does not mediate the relation between usefulness and intention to use. Hence, the higher usefulness of using HEMS in enhancing life quality, the more intention to use HEMS. While the perceived ease of use and usefulness have insignificant effects on the attitude toward use. In light of the findings, policymakers should take measures that accentuate the economic benefits for energy consumers and the positive impact on the environment of adopting HEMS and draw up policies that support these factors.

The researchers can use the above-mentioned findings as a foundation to further develop the proposed model and explore additional factors that could potentially impact consumer acceptance in Spain. By doing so, researchers can offer policymakers a richer understanding of the factors at play, thereby assisting in the formulation of more effective strategies aimed at enhancing consumer acceptance of the new electricity tariff. To gain a more comprehensive understanding of the subject in Spain, it is highly advised to broaden the scope of the research by increasing the sample size and carrying out a larger-scale survey encompassing various cities across the country. Such an approach would yield more comprehensive and robust results, contributing to a more thorough comprehension of consumer's behavior and preferences related to the new tariff.

Implications and influences

This study focuses on the factors that might affect energy consumers in managing energy consumption in response to the grid status. This work was implemented after applying a new electricity tariff in Spain. The insights gleaned from this research can serve as a valuable guide for researchers and those drawing up policies to support the renewable energy sector and encourage energy consumers to participate in energy security by managing energy consumption efficiently.

Abbreviations

AGFI	Adjusted Goodness of-Fit-Index
AMOS	Analysis of a Moment Structures Software
ATT	Attitude Towards Use
C.R.	Critical Ratio
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CO_2	Carbon dioxide
CR	Composite Reliability
DF	Degrees of Freedom
DR	Demand Response
FEB	Family's Economic Benefits
IEA	International Energy Agency
INT	Intention to Use
GFI	Goodness of-Fit-Index
HEMS	Home Energy Management System
IFI	Incremental Fit Index
NFI	Normed Fit Index
P-value	Probability value
PE	Ease of Use
PU	Perceived usefulness
PV	Photovoltaic
PW	Perceived Environmental Awareness
RES	Renewable Energy Sources
RMSEA	Root Mean Square Error of Approximation
SE	Standard Error
SEM	Structural Equation Modeling
SG	Smart Grid
SPSS	Statistical Package for the Social Sciences Software
TAM	Technology Acceptance Model
X^2	Chi-square

Definitions

Adjusted Goodness of-Fit-Index (AGFI)
A statistical measure to assess how well a proposed model fits the observed data considering the degrees of freedom
Chi-square (X^2)
A test that measures how a model compares to actual observed data, is compared to a critical value from the chi-square distribution to determine statistical significance
Composite Reliability (CR)
A measure of the consistency and reliability of a multi-item scale
Comparative Fit Index (CFI)
A statistical measure analyzes the model fit by examining the discrepancy between the data and the hypothesized model while adjusting for the issues of sample size inherent in the chi-squared test of model fit, and the normed fit index
Confirmatory Factor Analysis (CFA)
A statistical technique used to test and confirm the underlying factor structure of a set of observed variables
Critical Ratio (C.R.)
A statistical measure used to determine the significance of individual path coefficients or parameter estimates in the SEM. It assesses whether specific relationships between variables are statistically significant
Degrees of Freedom (DF)
A statistical concept representing the number of values in the final calculation of a statistic that are free to vary
Goodness of-Fit-Index (GFI)
A statistical measure assessing how well a model fits observed data

Incremental Fit Index (IFI)
A statistical measure indicating the improvement in model fit when adding additional parameters to a model
Normed Fit Index (NFI)
A statistical measure evaluating the goodness of fit of a model by comparing it to a null model
Probability value (P-value)
A statistical measure employed to assess the compatibility of a hypothesis with observed data)
Root Mean Square Error of Approximation (RMSEA)
A statistical measure used to evaluate the goodness of fit of the model by quantifying the level of discrepancy between the model's predictions and the actual data
Standard Error (SE)
A measure of the variability or uncertainty associated with parameter estimates in a structural equation model indicates how much the estimated values may deviate from the true values
Structural Equation Modeling (SEM)
A statistical method for analyzing relationships among variables

Scales

Adjusted Goodness of-Fit-Index (AGFI)
Range from 0 to 1, where higher values indicate better fit
Comparative Fit Index (CFI)
Range from 0 to 1, with higher values indicating better fit
Composite Reliability (CR)
CR>0.6
Critical Ratio (C.R.)
Higher than 1.96
Goodness of-Fit-Index (GFI)
Range from 0 to 1, where higher values indicate better fit
Incremental Fit Index (IFI)
Range from 0 to 1, higher IFI values are preferred and indicate better fit
Normed Fit Index (NFI)
Range from 0 to 1, with higher values indicating better fit
Probability value (P-value)
P-value < 0.05
Root Mean Square Error of Approximation (RMSEA)
Range from 0 to 1, with lower values indicating better fit
Standard Error (SE)
The smaller the standard error the better

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Conflict of interest

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

Author contribution statement

Conceptualization, Z.A.A.M. and P.M.B.B.; methodology, Z.A.A.M., M.A.B.I. and P.M.B.B.; software, Z.A.A.M., M.A.B.I. and P.M.B.B.; validation, P.M.B.B., J.J.F.R. and Z.A.A.M.; formal analysis, Z.A.A.M. and M.A.B.I.; investigation, Z.A.A.M. and P.M.B.B.; resources, Z.A.A.M. and P.M.B.B.; data curation, Z.A.A.M., M.A.B.I. and P.M.B.B.; writing—original draft preparation, Z.A.A.M. and M.A.B.I.; writing—review and editing, Z.A.A.M. and P.M.B.B.; visualization, Z.A.A.M. and P.M.B.B.; supervision, P.M.B.B. and J.J.F.R.; project administration, Z.A.A.M., P.M.B.B. and J.J.F.R. All authors have read and agreed to the published version of the manuscript.

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