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## Article

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# ALIGNING PUBLIC POLICY WITH REPOWEREU PROGRAM OBJECTIVES BY ADOPTING EESS SOLUTIONS: A TECHNOLOGY ACCEPTANCE MODEL APPROACH

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## Abstract

The achievement of short-term energy savings through changes in user consumption behaviour is one of the main directions addressed by the REPowerEU program. This paper investigates the perspective of increasing energy efficiency at the level of domestic consumers in Romania by adopting energy efficiency smart solutions (EESS). The research is based on the extended technology adoption model and analyses the behaviour of Romanian consumers regarding the intention to use EESS solutions, in relation to three main influencing factors (awareness, environmental protection considerations, and public policy) moderated by demographic factors. To validate the research hypotheses, a survey was organised between January and March 2023, and structural equation modelling was used to highlight the effects of the determining factors on adoption intention. The research results suggest that all the predictors considered positively influence the behavioral intention to use EESS, with public policy having the greatest effect, followed by awareness. The results obtained suggest that the behaviour of household energy consumers towards adopting EESS is different depending on their age and average income. Additionally, through the IMPA model, a series of managerial interventions are formulated, mainly targeted at the authorities, in order to align Romanian public policies with the objectives of the REPowerEU program, in the

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context of promoting voluntary measures geared to the lifestyle and behaviour of household consumers by adopting EESS solutions.

The limits of the research mainly refer to the lower familiarity acquired as a result of experience in use, in the context of the still early stage of development of the analysed technologies, but also to the exclusion from the analysis of some constructs of the extended model of technology acceptance, such as hedonic motivation or social influences, which would have allowed a more precise understanding of consumer attitudes.

**Keywords:** energy efficiency, public policies, the technology acceptance model, TAM, UTAUT, UTAUT2, smart devices, EESS

**JEL classification:** O33, Q48, Q58

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## **Introduction**

The REPowerEU program (European Commission, 2022) includes ambitious objectives regarding energy savings in a two-tier approach: on the one hand, by implementing measures to increase energy efficiency in the medium and long term, and on the other hand, by making short-term savings through changes in the consumption behaviour of users. Therefore, in collaboration with the International Energy Agency (IEA), the European Commission (EC) launched the “*Playing my part*” plan (2022), an integral part of the REPowerEU Program that defines nine categories of voluntary measures brought to the lifestyle and behaviour of different types of energy users, in order to achieve short-term savings. According to this plan, the installation of digital thermostats or smart devices to control energy consumption would allow for 15% savings in energy consumption, while optimising consumption in such a way that users can benefit from the lowest electricity prices. AIE estimates (AIE and European Commission, 2022) that the application of the “*Playing my part*” the plan may lead to a reduction of approximately 5% of gas consumption (approx. 13 billion m<sup>3</sup>) and oil (approx. 16 mtoe). At the same time, some research (Mrazek et al., 2022) shows that homes contribute to global energy consumption with percentages between 20% and 40%, therefore optimizing household consumption directly contributes to reducing energy dependencies at EU level and achieving the strategic objectives of the REPowerEU program.

In the context of the recommendations provided by the REPowerEU Program, this research addresses the perspective of the voluntary change in the consumption behaviour of users through the assimilation of smart devices for energy consumption control, hereinafter referred to as EESS (Energy Efficiency Smart Solutions), a category that includes a wide range of smart devices based on IoT such as smart bulbs, smart sockets, smart meters, or smart thermostats.

The approach of carrying out such research at the Romanian level, a country for which REPowerEU is a key reference document for energy policy, also aligns with the results of previous relevant research carried out at the level of other countries, with the aim of analysing the attitude of household consumers regarding the adoption of assimilated EESS technologies (automated sensor and control systems, “Smart Home” solutions, HVAC systems, etc.) using the initial technology acceptance model (TAM) or its extended versions (UTAUT and UTAUT2). Among the studies analysed and discussed extensively in the following sections, we can mention those carried out at the level of consumers in Indonesia (Chou and Yutami, 2014), Malaysia (Kardooni et al., 2019), Japan (Chen et al., 2020), UK (Whittle et al., 2020)

or the USA (Chen et al., 2020), Brazil (Gumz et al., 2022), Chile (Humeres, 2022), Denmark (Billanes and Enevoldsen, 2022), Germany (Große- Kreul, 2022).

Based on the analysis of consumer behaviour regarding the intention to use EESS solutions, the purpose of the research is to identify possible directions of managerial intervention that allow a better focus of public policies in Romania in relation to the objectives of the REPowerEU Program, by accelerating the adoption of EESS at the level of different categories of household energy consumers. From this perspective, addressed in Section 2, the research aligns with other studies (Kardooni et al., 2016; Girod et al., 2017; Jones and While, 2020; Billanes and Enevoldsen, 2022), which emphasised the role of public policies as a tool to raise awareness and improve the attitude of consumers regarding the adoption of EESS solutions, as well as to disseminate these technologies, including in terms of environmental considerations (Gimpel et al., 2020; Gumz et al. , 2022; Ferreira et al., 2023).

The present research is organised as follows. Section 1 includes the theoretical framework and a review of the literature. In Section 2, the research hypotheses are developed according to the extended technology acceptance model (TAM). Section 3 includes the materials and methods used. In Section 4, the research results are presented, followed by a discussion and presentation of the implications of the research results in Section 5. Finally, the last section contains the conclusions of the article.

## 1. The theoretical framework

According to estimates (Shuhaiber and Mashal, 2019), the global IoT market is expected to grow to \$11.1 trillion by 2025. The adoption of EESS-like solutions by household consumers is a topic of widespread attention in research. Some research (Girod et al., 2017; Große-Kreul, 2022; Billanes and Enevoldsen, 2022) places these solutions in the category of SET (Smart Energy Technologies), defined as energy-saving technologies that include sensors and automatic control, such as solar panels, HVAC systems, smart home devices, smart metres, energy monitoring and control systems, or electric vehicles (Billanes and Enevoldsen, 2022). Some authors (Shin et al., 2018; Shuhaiber and Mashal, 2022; Ferreira et al., 2023) classify EESS solutions in the Smart Home category, which includes control and automation technologies for lighting and heating systems (e.g., smart thermostats), ventilation, air conditioning, and smart appliances. Other authors (Chin and Lin, 2015; Whittle et al., 2020; Chen et al., 2020) classify smart technologies for energy efficiency in the HEMS (Home Energy Management System) or BEMS (Building Energy Management System) categories, defined as systems that allow consumers to manage energy consumption more effectively through behavioural changes (Whittle et al., 2020).

The literature review revealed a series of research on the application of the technology acceptance model (TAM) in the sector of EESS solutions. Chou and Yutami (2014) used structural equation modelling to analyse Indonesian consumers' propensity to adopt smart metres in residential buildings. Other research on the application of TAM for the adoption of smart metres was carried out in Chile (Humeres, 2022) or Brazil (Gumz et al., 2022); in the latter case, the UTAUT2 model was used. Shuhaiber and Mashal (2022) investigated factors that influence the acceptance and use of smart home technologies among household consumers. Ferreira et al. (2023) applied the UTAUT2 model to explore the effects of environmental impact awareness on individual intentions and behaviour towards Smart

Home technologies. Shin et al. (2018) used the TAM model to describe the factors influencing the adoption of Smart Home, also considering a number of specific factors such as the network connectivity of various smart devices or the importance of protecting personal information. Some authors (Attie and Meyer-Waarden, 2022) approached the adoption of smart solutions for energy efficiency from the perspective of SCO (Smart Connected Objects), in a longitudinal study conducted on 702 respondents at the level of 3 years of acceptance and use, which showed that TAM variables remain relevant in the context of SCO (smart thermostats, security systems, or energy control systems). Other authors (Whittle et al., 2020) applied the TAM model to assess the intention to use HEMS solutions in UK household consumers, focusing on their attitude towards environmental protection. Another study focused on the acceptance of HEMS (Chen et al., 2020), based on a comparative analysis from the United States and Japan, shows that perceived usefulness, favourable attitude towards technology, and social norms are positively associated with the intention of adopting. Other research (Girod et al., 2017) investigated the pattern in which beliefs about green technology are influenced by personal norms regarding environmental protection and innovation. An extensive study (Billanes and Enevoldsen, 2022) carried out on 3000 residents from different cities in Denmark was based on the TAM model to which were added a series of external factors (e.g., knowledge, public policies, social influences, or awareness) were added that influence the behavioral intention to adopt SET solutions in residential conditions. Große-Kreul (2022) applied the UTAUT2 model to assess the acceptance of SET among 700 German household consumers. Other authors (Kardooni et al., 2019) applied the TAM model to analyse the acceptance of technological solutions for energy efficiency in Malaysia. The perspective of the role of public policy as an external factor of the TAM model was addressed by Choi (2022) and by Gimpel et al., (2020) in a research based on 4000 subjects from Europe, Asia and North America that showed that attitude and performance expectations are the primary determinants of the adoption of smart energy technologies, under the influence of environmental protection attitude. Chin and Lin (2015) extended the TAM model with two other external factors, namely compatibility (C) and technology complexity (TC), to evaluate the implementation of BEMS-related technologies. Finally, at the Romanian level, some studies approach the TAM model in the context of explaining the intention to use smart grid technologies (Ianole-Călin and Druică, 2022), and others from the perspective of Romanian consumers' interest in technological autonomy and the benefits brought in the plan energy savings by adopting IoT devices (Micu et al., 2021).

## **2. Development of research hypotheses**

The Technology Acceptance Model (TAM) is one of the most common models used to analyse user behavior in relation to the acceptance and use of new technologies. The initial version of the model (Davis, 1989) uses four main constructs, namely intention to use, attitude toward use, perceived usefulness, and ease of use. Subsequently, the UTAUT (Venkatesh et al., 2003) and UTAUT2 (Venkatesh et al., 2012), which added a number of new constructs such as behavioural intention, hedonic motivation, perceived cost, or social influences, also analyzing the impact of the moderating effect of facilitating conditions of age, gender, and experience. To analyse the attitude of consumers about the acceptance of EESS assimilated solutions, the literature review revealed other constructs added to the three main models, which influence the behavioural intention to use these technologies, namely: the attitude regarding the use of technology (Kardooni et al., 2016; Shuhaiber and Mashal,

2019; Wang et al., 2022), attitude regarding environmental protection (Girod et al., 2017; Whittle et al., 2020; Große-Kreul, 2022; Gumz et al., 2022), internalisation of objectives (Whittle et al., 2020), perceived risks (Chou and Yutami, 2014; Shuhaiber and Mashal, 2019; Choi, 2022; Ianole-Călin and Druică, 2022), public policies (Billanes and Enevoldsen, 2022; Wang et al., 2022) or trust in technology (Shuhaiber and Mashal, 2019). Based on the models analysed, but also on the specifics of the research topic, the proposed conceptual model (Figure no. 1) is based on five hypotheses.

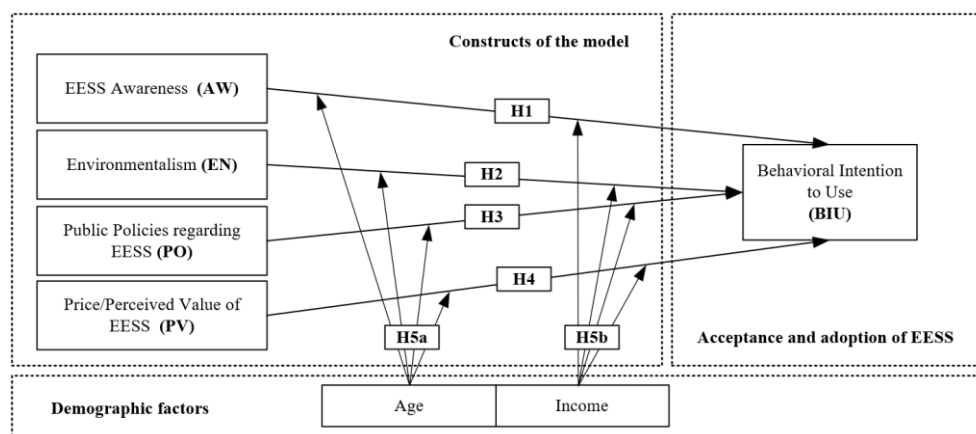


Figure no. 1. Conceptual model and research hypotheses

Taking into account the novelty of EESS technologies and the higher level of complexity of these technologies in terms of functionality and usage, the first direction addressed is the level of awareness of users of EESS and the benefits of these technologies. According to some authors (Kardooni et al., 2016; Jones and While, 2020; Billanes and Enevoldsen, 2022), awareness represents a focus direction of public policy in the sphere of energy efficiency. In addition, public awareness is one of the objectives pursued by the REPowerEU program, conducted through the “*Playing my part*” awareness campaign. Awareness of EESS technologies is a construct that is used in other TAM-based research as well. Shuhaiber and Mashal (2019) use awareness as an additional factor of the TAM model in order to analyse the impact on consumer attitudes regarding the use of Smart Home technologies, also taking into account the phenomenon of familiarity, which shows the level of awareness as a result of experience in use. Chow and Yutami (2014) showed that the level of awareness is one of the influential factors of users' intention to adopt smart metres. Billanes and Enevoldsen (2022) showed the positive influence of awareness as an influential factor for the adoption of SET technology. Therefore, we formulate the following hypothesis:

*Hypothesis 1 (H1): Awareness of EESS (AW) positively influences the intention of using them (BIU).*

The “*Playing my part*” plan, an integral part of the REPowerEU program, is a campaign to raise awareness of the benefits of energy savings achieved through changes in consumption behaviour, with the goal of increasing energy efficiency, simultaneously with supporting climate actions. The perception of environmental issues by users thus becomes an essential factor in the voluntary acceptance of the measures proposed by the REPowerEU program. The use of environmental protection attitudes as a construct of the TAM model can be found

in previous research with applicability in the sphere of ESS assimilated technologies. The attitude towards environmental protection is closely related to awareness, that is, the degree to which people are concerned and aware of environmental changes and the problem of global warming (Gumz et al., 2022). However, (Billanes and Enevoldsen, 2022) believe that although the public is aware of environmental aspects, many users are somewhat reluctant to accept SET solutions. In another study (Wang et al., 2022), it is shown that the acceptance of electric vehicles is significantly positively influenced by environmental awareness. Other authors (Gimpel et al., 2020) analysed the correlations between environmental concerns and specific beliefs about technology, showing that an increase in the first variable would correspond to an increase in the second, while a negative relationship indicates an inverse relationship. Ferreira et al., (2023) show that, taking into account the energy benefits offered by Smart Home technologies, individuals with a higher level of environmental awareness would be more willing to buy and use these technologies, and to recommend them to others. Therefore, we formulate the following hypothesis:

*Hypothesis 2 (H2): Environmental considerations (EN) positively influence the intention to use EESS (BIU).*

The analysis of the impact of public policies on the attitude of consumers regarding the adoption of EESS solutions constitutes one of the main directions of research addressed by this article, which aims to formulate a proposal to align public policies in Romania with the objectives of the REPowerEU program, respectively, with the policy recommendations defined in the plan “*Playing my part*”. Previous studies have confirmed the strong link between public policy and the acceptance of EESS-related technologies. Billanes and Enevoldsen (2022) demonstrated the significant influence of effective policies on the adoption of SET, but also demonstrated that policies can be used as tools both to increase consumer awareness and to accelerate the diffusion of new technologies by providing incentives. In a study conducted in Great Britain, Jones and While (2020) showed how the application of public policies such as those based on the promotion of new technologies would contribute to increasing acceptance, a relationship mediated by the internalisation of national energy objectives in shaping the intention to use HEMS. Some authors (Girod et al., 2017) have shown that policies that incentivize merchants to sell SET solutions are an effective approach to increase the widespread adoption of these technologies, and other authors (Kardooni et al., 2016) showed that public policies in the field of renewable energy should address public awareness and perception. On the other hand, public policies can contribute to the transfer of new technologies (including those aimed at energy efficiency) to the economic environment, in order to be available to final consumers (Stefan et al., 2020). Therefore, we formulate the following hypothesis:

*Hypothesis 3 (H3): Public policies regarding EESS (PO) positively influence the behavioral intention to use them (BIU).*

Given that EESS essentially represent technologies based on IoT, sensors, or automatic measurement and control systems, usually also incorporating a software component, the prices of these solutions are generally higher than those of other products with a similar purpose. Analysis of specialised literature (Girod et al., 2017; Billanes and Enevoldsen, 2022) shows that public policies in the field often act precisely on the price of specific technologies, with the aim of accelerating their acceptance at the market level. The price, respectively, the perceived value, represents a construct of the UTAUT and UTAUT2 models, used as a predictor of the

behavioural intention to use a technology (Venkatesh et al., 2003; Venkatesh et al., 2012). The price/perceived value has been included as a construct of the extended TAM model in a number of studies on the adoption of smart systems for energy efficiency. Girod et al., (2017) have shown that price or price value is the main target of environmental policies, or that the influence of personal norms is higher in relation to perceived utility and price value. Other authors (Kardooni et al., 2016) showed that perceived usefulness (PU) and perceived ease of use (PEOU) are indirectly influenced by the cost of EESS-assimilated technologies. Choi (2022) showed that the perceived level of cost of a smart technology does not negatively affect the intention to use it. However, Chou and Yutami (2014) analysed the influence of the electricity price on perceived risk, in the context of a TAM model for analysing the adoption of smart meters. Therefore, we formulate the following hypothesis:

*Hypothesis 4 (H4): The price / perceived value of EESS (PV) positively influences the behavioural intention to use them (BIU).*

To analyse the specific facilitating conditions of the extended TAM model, but also to rigorously delimiting consumer groups, two demographic factors were selected for this research, namely, age and income level. Age is an influencing factor included in the UTAUT and UTAUT2 models, which in correlation with gender and experience can moderate the effects of facilitating conditions on behavioural intention to use technology (Venkatesh et al., 2003; Venkatesh et al., 2012). The level of income is relevant because public policies in the field of energy are often correlated with the income of the population. In Romania, categories of vulnerable consumers in terms of income (under 2000 RON/ cohabitant at the level of consumption place) benefit in 2023 from subsidising the price of energy using energy cards as a tool. Following the application of the TAM model in the field of EESS specific technologies, some authors (Girod et al., 2017) concluded that young people with high income are more likely to adopt smart thermostats. Große-Kreul (2022) identifies the appropriate level of income as one of the prerequisites for the adoption of smart home technology. At the level of Romania, other authors (Ianole-Călin and Drucă, 2022) show that income level significantly influences perceived ease of use, with the highest levels being recorded in high-income groups. Therefore, we formulate the following hypothesis:

*Hypothesis 5 (H5): Age and income level moderate the aforementioned effects.*

### 3. Materials and methods

To provide the data necessary to answer the research question and validate the proposed hypotheses, a survey was used, with the online questionnaire as the data collection tool. The questionnaire was distributed between January and March 2023, the target population being represented by electricity household consumers.

To measure the concepts included in the conceptual model and to which the research hypotheses refer, five scales were adapted from the existing literature, their items being measured on a scale from 1 to 5 (strongly disagree - strongly agree). The five scales refer to: Behavioural intention to use EESS – BIU (Davis, 1989; Venkatesh et al., 2003; Venkatesh et al., 2012), Awareness – AW (Kardooni et al., 2016; Jones and While, 2020; Billanes and Enevoldsen, 2022), Environmental protection considerations – EN (Gimpel et al., 2020; Wang et al., 2022; Gumz et al., 2022; Billanes and Enevoldsen, 2022; Ferreira et al., 2023), Public policies – PO (Kardooni et al., 2016; Girod et al., 2017; Jones and While, 2020; Billanes and Enevoldsen, 2022) and Price/perceived value - PV (Venkatesh et al., 2003;



Venkatesh et al., 2012; Chow and Yutami, 2014; Girod et al., 2017; Choi, 2022). The items of the scales were adapted to the purpose of the research and the target population. At the same time, several items were added that more accurately describe the current context of the investigation. The questionnaire also included age (Venkatesh et al., 2003; Venkatesh et al., 2012) and average monthly income per family member (Girod et al., 2017; Große-Kreul, 2022; Ianole-Călin and Druică, 2022), factors hypothesised to drive differences in household consumer behaviour towards EESS adoption. Before accessing the questionnaire, the respondents were presented with the purpose of the investigation, informed about the confidentiality of the answers provided. The consent of the respondents to participate in the survey was obtained.

Of the 307 completed questionnaires, five were eliminated in the initial stage of data selection due to the fact that they included the same answer for all items, so the database on which the analysis was carried out included 302 cases. The largest share of respondents was represented by women (57.6%), living in urban areas (85.4%), and an average age of 37.46 years. 85.4% of the respondents have at least a bachelor's degree or equivalent, which is also reflected in a relatively high share of those with incomes greater than 4000 RON (55.6%).

To highlight the effects of determinants on the intention to adopt EESS by household consumers, structural equation modelling (PLS-SEM) was used through the SmartPLS 4 application (Ringle, Wende and Becker, 2022). Therefore, the intensity and statistical significance of the structural relationships could be evaluated to validate the research hypotheses H1-H4. Since differences in the effect of the four determinants of the intention to adopt EESS according to different characteristics of household consumers were hypothesised (H5), multigroup analysis (MGA) was adopted (Cheah et al., 2020). Significant differences between the two pairs of predefined groups, according to average monthly income per family member (< 2000 RON and > de 2000 RON) and age (< 30 years and > 30 years), were highlighted by the bootstrapping technique with 5000 subsamples and bias-corrected confidence intervals (BCCI). In the last stage of the research, the results obtained through PLS-SEM were extended by building two importance performance matrices (IMPMA) (Ringle and Sarstedt, 2016). Therefore, contrasting the standardised total effects taken from the PLS-SEM model (performance) and the rescaled scores in the range of 0-100 of the latent variables (importance), it was possible to highlight areas of managerial intervention, characterised by high importance and relatively low performance, which could lead to an increase in the intention of household consumers to adopt EESS.

#### **4. Results**

The validation of the PLS-SEM model involved, in two successive stages, the evaluation of the measurement and the structural model (Hair et al., 2019; Nae et al., 2020). The reliability and validity of the measurement model were evaluated using the PLS-SEM algorithm and following the evaluation framework proposed by Hair et al. (2019). Indicator loadings (>0.708), composite reliability (>0.7), and Cronbach Alpha coefficient (>0.7) (Table no. 1) produced values that support the reliability of the model. Furthermore, the values of the extracted average variance (AVE>0.5) indicate that each construct explains more than half of the variance of its indicators, thus supporting their good convergent validity (Hair et al., 2019).

**Table no. 1. Reliability and validity of the measurement model**

Constructs	Items	Loadings	Cronbach Alpha	rho_a	rho_c	AVE
<b>AW</b>	6	0.775-0.879	0.929	0.934	0.943	0.701
<b>BIU</b>	8	0.874-0.935	0.969	0.970	0.974	0.824
<b>EN</b>	8	0.815-0.893	0.950	0.957	0.958	0.740
<b>PO</b>	7	0.814-0.857	0.925	0.930	0.939	0.688
<b>PV</b>	5	0.683-0.901	0.857	0.874	0.899	0.643

Notes: EN = Environmental considerations, AW = Awareness, BIU = Behavioral intention to use EESS, PO = Public policies, PV = Perceived price/value, AVE = average variance extracted.

Regarding discriminant validity, both the Fornell-Larcker criterion (Fornell and Larcker, 1981) and the HTMT ratio (Henseler et al., 2015) provide arguments in favor of it (Table no. 2).

**Table no. 2. Discriminant validity**

Constructs	Fornell-Larcker criterion					HTMT ratio				
	AW	BIU	EN	PO	PV	AW	BIU	EN	PO	PV
<b>AW</b>	0.838									
<b>BIU</b>	0.592	0.908				0.615				
<b>EN</b>	0.410	0.575	0.860			0.423	0.587			
<b>PO</b>	0.424	0.707	0.581	0.829		0.442	0.736	0.610		
<b>PV</b>	0.411	0.538	0.397	0.479	0.802	0.445	0.581	0.433	0.534	

Notes: EN = Environmental considerations, AW = Awareness, BIU = Behavioral intention to use EESS, PO = Public policies, PV = Perceived price/value.

The second stage of the evaluation of the PLS-SEM model involves the evaluation of the structural model. In this sense, possible multicollinearity problems between the predictors were first ruled out, with VIF values ranging between 1.357 and 1.610, below the threshold of 3 (Hair et al., 2020). From the perspective of the coefficient of determination ( $R^2$ ), it can be stated that the model has a high explanatory power, the four predictors, namely awareness, environmental protection considerations, public policy and price/perceived value, which explain almost two thirds of the variance of the behavioral intention to adopt EESS ( $R^2 = 0.640$ ).

To confirm the research hypotheses, the value and statistical significance of the standardised path coefficients ( $\beta$ ) were evaluated. As can be seen in table no. 3, all four considered predictors positively influence the behavioural intention to use EESS. Of these, public policies have the greatest effect ( $\beta = 0.424$ ;  $p < 0.001$ ;  $f^2 = 0.285$ ), followed by awareness ( $\beta = 0.287$ ;  $p < 0.001$ ;  $f^2 = 0.169$ ), while considerations related to environmental protection determine the adoption of EESS by household consumers to the smallest extent. Considering the above, hypotheses H1-H4 are supported. It can also be seen that all four exogenous constructs have a predictive ability, evidenced by the size of the effect ( $f^2$ ), for two of these (AW and PO) to be of medium level ( $> 0.15$ ), and for EN and PV – low level ( $> 0.002$ ) (Cohen, 1988).

**Table no. 3. Direct effects**

hypotheses	Relationships	Beta Std.	Std. error	T statistic	Effect size ( $f^2$ )
<b>H1 (+)</b>	AW $\rightarrow$ BIU	0.287***	0.045	6.352	0.169**
<b>H2 (+)</b>	EN $\rightarrow$ BIU	0.148**	0.051	2.919	0.038
<b>H3 (+)</b>	PO $\rightarrow$ BIU	0.424***	0.056	7.553	0.285**
<b>H4 (+)</b>	PV $\rightarrow$ BIU	0.158***	0.046	3.466	0.049

Notes: \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

To highlight the existence of significant differences in the effects of AW, EN, PO, and PV on the intention to adopt EESS by household energy consumers (H5), a multigroup analysis was used (Cheah et al., 2020), the results are illustrated in table no. 4. As can be seen, the MGA revealed significant differences between the group of respondents aged less than 30 years and those above this age in terms of the effects of AW, EN, and PV, while the average level of income causes significant differences only on the influence of AW on the intention to adopt EESS. Therefore, it should be noted that AW determines to a greater extent the increase in the intention to adopt EESS for people over 30 years of age and income greater than 2000 lei, while the effect of EN and PV is stronger among young people.

**Table no. 4. Multigroup analysis**

Relationships	Age			Income level		
	< 30 years	> 30 years	$\Delta\beta$	< 2000 RON	> 2000 RON	$\Delta\beta$
AW → BIU	0.172**	0.358***	-0.186*	0.030	0.325***	-0.295*
EN → BIU	0.284***	0.047	0.237**	0.353**	0.111*	0.242
PO → BIU	0.339***	0.480***	-0.141	0.307*	0.440***	-0.133
PV → BIU	0.256**	0.093*	0.163*	0.251	0.143**	0.107

Notes: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

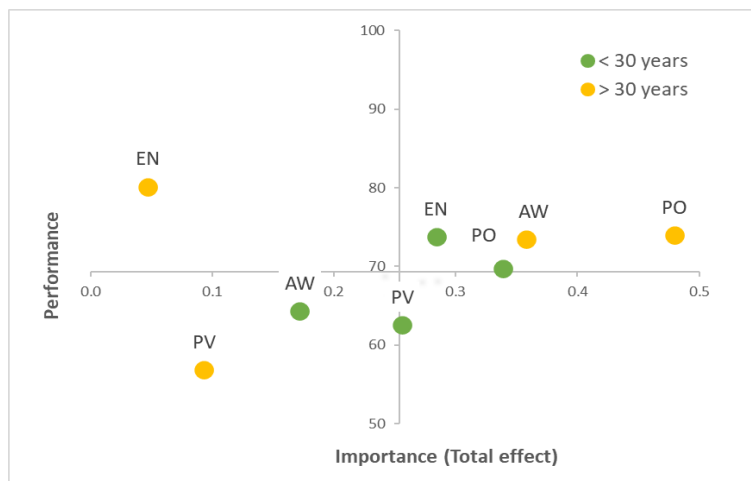
Differences in perception between the analysed consumer groups can be explained in relation to several contextual factors. Therefore, from the perspective of income, the level of awareness is higher for consumers whose monthly income exceeds 2000 RON per family member, under the impact of higher energy costs (2000 RON is the maximum ceiling established in Romania for partial subsidisation of energy electrical price). At the same time, the higher impact of environmental protection considerations for young people is explained, on the one hand, by the education level (this group of consumers included, to a large extent, respondents who have at least a bachelor's degree or equivalent), and on the other hand by the ever-wider promotion, especially through social influences, of good practises regarding environmental protection. In this sense, other research (Schepers and Wetzels, 2007; Gumz et al., 2022) indicates a more important role of social influence for young people.

## 5. Implications of research results and discussions

The previous analyses provide useful information on the intensity of the effects of some determining factors on the intention of household consumers to adopt EESS, and particular elements are also highlighted for certain groups of consumers. However, since the purpose of the article also includes the suggestion of possible directions of managerial intervention in public policies aimed at enhancing the use of EESS and by larger social groups, the analysis was extended with the help of IMPA (Ringle and Sarstedt, 2016). Thus, two matrices were created (Figure no. 2 and Figure no. 3), which illustrate priority intervention areas with over importance and relatively low performance (lower-right quadrant) or with performance that, although quite high, can still undergo improvement (right- up quadrant).

As can be seen in figure no. 2, the most relevant public policy directions addressed to young people under 30 years of age should address the perceived value of EESS and the attitude of environmental protection, while in the case of users over 30 years of age, public policy should be primarily oriented towards awareness of the role and usefulness of EESS technologies. We therefore appreciate that, in order to increase the degree of adoption of EESS technologies, the authorities should focus on a mix of public policies that could include the

granting of fiscal incentives for the commercialisation/purchase of EESS, the implementation of grant systems/ subsidies, or the running of campaigns to promote and raise awareness of voluntary measures to reduce energy consumption addressed to domestic users. Considering the above-mentioned results, in order to maximize the impact, awareness campaigns should be focused, first of all, on the level of consumers with medium and high incomes and over 30 years of age.

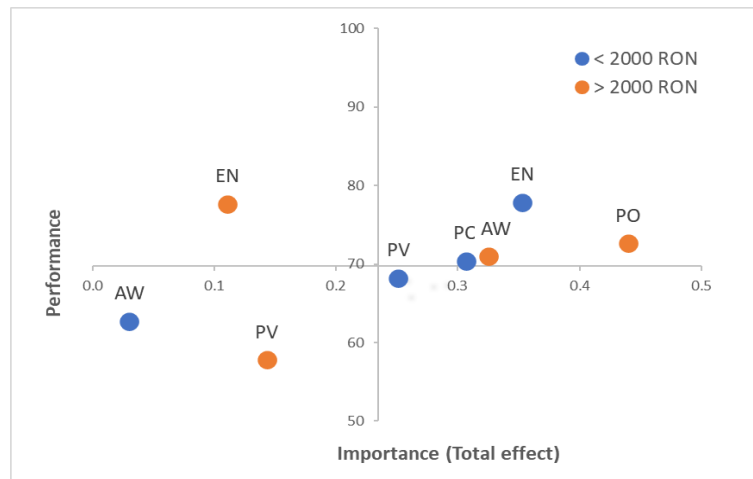


**Figure no. 2. Importance – Performance Matrix based on age groups**

Regarding the membership of consumers in groups determined by income level (Figure no. 3), it can be seen that for people with lower levels of average income per family member (< 2000 RON), public policies to stimulate the use of EESS should focus primarily on increasing the perceived value of EESS, but also on policies to stimulate the use of EESS and awareness of the positive effects on the environment. For example, the current energy price subsidy system applicable in Romania starting from 2023 by granting energy cards to consumers with an income per family member below 2000 RON, which could include a component of financing the costs of purchasing certain types of EESS solutions, in compliance with a certain regulated ceiling. On the other hand, in the case of household users with incomes greater than 2000 RON/person, the focus directions of public policies should primarily aim at increasing the level of awareness of users regarding EESS technologies and the benefits of these technological solutions in the sphere of energy efficiency.

Research contributes to the creation of the general framework of strategies and public policies related to the REPowerEU program, as it addresses in a practical way factors that can contribute to the achievement of short-term savings through changes in the consumption behaviour of users. The paper argues that the adoption of EESS technologies represents a feasible and immediate option to reduce energy consumption, as users in Romania are aware of the role and usefulness of these technologies. The strong correlation between public policies (PO) and behavioural intention to use (BIU), moderated by age and income level, indicates a potentially major impact of policies that could address the EESS technology sector. The research results are also relevant for companies active in the field of commercialising EESS devices, which should pay more attention to customer awareness actions to increase sales. In this category could be included dedicated marketing campaigns

focused equally on the awareness of customers regarding specific technologies, but also regarding environmental issues. The significant influence of PV on BIU shows the increased importance users attach to the perceived value of purchasing EESS. Therefore, industry manufacturers should focus on identifying technological solutions that improve the value-for-money and functionality of these solutions, for example, by developing a software component that makes the EESS control more efficient.



**Figure no. 3. Importance – Performance Matrix based on income groups**

The article makes a number of theoretical contributions. The proposed conceptual model extends the TAM model by adding three constructs (awareness, environmental protection attitude, and public policy) selected in such a way as to provide the most eloquent picture of how public policies in the field of energy should be aligned with consumer expectations in order to accelerate the adoption of EESS. Second, the application of the TAM model for the analysis of the acceptance of some devices for energy efficiency, such as EESS solutions, is less common in the specialised literature. Classical approaches of the TAM model are carried out in the field of IT&C and focus on the technical aspects related to the assimilation of technologies rather than those related to environmental protection and public policy. Finally, a closer look at the bibliographic resources shows that most of the research in the field, at the European level, was obtained on the basis of data collected at the level of some countries in western Europe. Therefore, the application of research at the Romanian level brings more knowledge that contributes to a better alignment of national policies in the energy field with the objectives of the REPowerEU program.

## Conclusions

The research results confirm the initial hypotheses in the sense that the acceptance of EESS technologies is strongly influenced by user awareness, attitudes towards environmental protection, public policies, and perceived value, with these effects being moderated by the classification of household consumers by age groups and income level. Therefore, the study supports the previous results on the adoption of EESS-assimilated technologies, which aimed at modelling the intention behavioural to use them under the impact of the mentioned

determinants. From the point of view of practical implications, through the proposals for managerial intervention formulated within the IMPA model, possible solutions are identified to increase the intention of household consumers to adopt EESS, which can be integrated into Romanian public policy, in order to align with the objectives of the REPowerEU programme. Other practical implications concern the private sector, as the results obtained indicate possible directions of action for companies in the industry to increase sales by improving the level of awareness about EESS and optimizing the value for money of these technologies. It also shows how to align these public policies according to specific elements defined at the level of certain categories of users.

The research results also contribute to the improvement of knowledge in the field of the application of public policies intended for the energy sector, a relevant aspect especially from the perspective of the current geopolitical context and the European Union concerns on the rapid implementation of recovery and resilience measures. At the same time, research brings more knowledge at the level of a niche segment, since most previous researches rather address the energy efficiency policies addressed to the industry or transport sectors, at the expense of promoting voluntary measures brought to the lifestyle of users in order to reduce energy consumption.

This research also has certain limitations. First, only part of the variables of the extended TAM model were selected in the investigation, excluding a series of constructs used in similar research that could have led to a more precise understanding of consumer attitudes toward EESS technologies. Among these constructs, which can be taken into account in future research, we mention hedonic motivation, social influences, trust, or internalization of objectives. Another limitation of the research concerns the structure of the sample, which largely included respondents who have at least a bachelor's degree or equivalent, which is also reflected in a relatively high proportion of those with high incomes. Third, it should be considered that the market for EESS technologies is still at an early stage of development, which means that the interpretation of the level of consumer awareness is less relevant in relation to the familiarity acquired as a result of the experience of use.

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