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USAGE INTENTIONS, ATTITUDES, AND BEHAVIORS TOWARDS ENERGY-EFFICIENT APPLICATIONS DURING THE COVID-19 PANDEMIC

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Abstract. Energy waste is an emerging issue worldwide, with energy conservation goals, such as conscious energy consumption, playing a crucial role in helping the environment. The rapid growth of smart appliances has led to the development of mobile applications, with an increased interest among policymakers to design eco-saving plans for optimizing power and battery consumption. This study aims to explore the usage intention of energy-efficient applications, through young consumers' energy conservation behavior, behavioral characteristics, and COVID-19 pandemic experience. Based on empirical investigation, a survey was applied in Romania among 590 mobile app users. The data were tested using partial least square structural equation modeling (SmartPLS, version 3). The results indicate the impact of behavioral characteristics, namely, energy conservation attitude, subjective norms, and environmental knowledge on young users' energy conservation behavior. The influential effect of COVID-19 on energy-saving behavior was also proven. Energy conservation behavior, and functional and hedonic values positively influence Millennials' and Gen Zers' energy-efficient app usage intentions. The study also discusses some implications for policymakers, marketers, and software developers, as well as providing theoretical suggestions for future work.

Keywords: energy conservation behavior (ECB), mobile apps, theory of planned behavior (TPB), COVID-19, energy conservation attitude, values.

JEL Classification: K32, M31, Q20.

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Introduction

Energy conservation and efficiency is gaining greater awareness, both among consumers and companies, due to environmental impact and the contribution of future 5G network technologies. Even so, consumers have insufficient knowledge about their energy consumption level, regardless of the technological devices used (e.g., home appliances, smartphones, etc.), this being one of the many challenges faced by the energy ecosystem. According to the European Commission (2016), for smart appliances, such as mobile/smartphones, there is a need to take into consideration an eco-design working plan due to their energy-saving potential. As the number of smartphones is rapidly increasing due the advancement of individual communication needs, and also to the fact that more and more producers and/or retailers have shifted their physical sales to online outlets (Lăzăroiu et al., 2020b; McKinsey & Company, 2020), more mobile applications have been developed in recent years.

The COVID-19 pandemic was an influential driving factor that also favored the development of mobile apps. Mobile apps are software run on mobile devices, offering information, services, and experiences through usage (Hsu & Lin, 2015). Considering the importance of energy conservation, the green trend has also arisen in the mobile application field. Some authors view green apps as those which focus on enhancing users' pro-environmental behavior (Barboza & Filho, 2019), while others highlight the importance of providing sustainability-related information, thus improving users' environmental knowledge (Brauer et al., 2016). Therefore, the term, "green" can have several meanings with one purpose – to behave in a more environmentally friendly way. In this regard, the present research considers those apps which help to reduce the environmental impact of the smartphone by optimizing power and battery consumption, namely energy-efficient mobile apps.

The energy efficiency of mobile applications is a hot research topic among software developers, focusing mainly on hardware optimization of mobile devices (Naik, 2010) and applications (Pathak et al., 2012). However, with the exception of a few studies (Heikkinen et al., 2012; Wilke et al., 2013), consumers' intention to rely on energy conservation apps is still under investigation. Heikkinen et al. (2012) suggest that the optimization of mobile energy consumption is an important issue among users, and the energy efficiency of apps influences users' rating decisions (Wilke et al., 2013). Some apps are developed to generate enjoyment for users, focusing primarily on stimulating hedonic motivation (e.g., Candy Crush, Angry Birds), while other apps are developed to satisfy functional tasks (e.g., Drive, PDF, Word). As hedonic values can be conceptualized as gamification elements (Dastane et al., 2020), gamified apps positively influence consumers' energy-saving behaviors (Mulcahy et al., 2020). The functional values of energy-efficient appliances could also shape consumers' environmental behavior (Waris & Hameed, 2020). Therefore, the examination of energy-efficient app usage intention forms a gap in the literature regarding mobile applications. Although energy saving is a frequently studied pro-environmental behavior (Yuriev et al., 2020), the literature merely analyses the prediction of energy conservation. Some potential explanatory variables, such as psychological factors in, e.g., knowledge, attitudes, subjective norms, motivations, and intentions were identified by Frederiks et al. (2015), while Yuriev et al. (2020) measure pro-environmental intention rather than behavior. Most approaches are based on the theory of planned behavior, although scholars tend to extend and adapt this theory by considering more variables/dimensions, such as moral norms, past behavior, and habits, which could increase its explanatory power to a certain extent.

The present research aims to fill the gap regarding energy conservation of mobile applications, proposing (1) to explore the predictors of energy-efficient mobile app usage intention, namely, the impact of energy conservation behavior, functional and hedonic values among young consumers; (2) to examine the antecedents of energy conservation behavior, such as energy-saving attitude, subjective norms, environmental knowledge, and collectivism, and (3) to highlight the impact of the COVID-19 pandemic on the usage and energy conservation behavior of mobile apps. COVID-19 represents a novelty context of the research due to its socio-economic and environmental impact.

The paper is structured as follows: after reviewing the literature on energy conservation and energy-efficient mobile apps in Section 2, Section 3 presents the hypotheses and conceptual model development. Section 4 deals with the research methodology and design, while Section 5 presents the results and discussion. The paper ends with conclusions, highlighting the theoretical and managerial implications, limitations, and future research perspectives.

1. Literature review

1.1. Theory of planned behavior in energy conservation behavior framework

The Theory of Planned Behavior (TPB) suggests that attitude, subjective norm, and perceived behavioral control predict behavioral intention, which in turn drives the actual act (Ajzen, 1991). According to the TPB, attitude reflects one's opinion of a behavior; subjective norm indicates an individual behavior due to social influence; and perceived behavioral control expresses a person's engagement with a behavior, depending on the perceived difficulty of that behavior (Ajzen, 1991). In recent years, TPB has become the most widely used model to predict pro-environmental behavior, such as recycling (Echegaray & Hansstein, 2017; Cantaragiu & Ghinea, 2020), green decision-making (Pop et al., 2020); energy saving (Wang et al., 2021), and purchase of energy-efficient appliances (Waris & Hameed, 2020). Literature has extended the TPB, adding more dimensions, such as knowledge (Wang et al., 2014; Waris & Hameed, 2020), demographical variables (Wang et al., 2014), personality traits (Wang et al., 2021), and functional values (Waris & Hameed, 2020) etc.

Due to the rapid changes in consumer behavior and technology, energy consumption has become an important and relevant topic, both for companies (Everis & NTT DATA, 2017) and academia (Pihkola et al., 2018). Hartmann and Apaolaza-Ibáñez (2012) studied consumers' green energy attitudes and found that utilitarian benefits have a significant impact on consumers' purchase intention, and that attitude towards green energy brands partially mediates this relationship. They also argued that green energy purchase intentions can be influenced by environmental concerns and by psychological benefits, such as a warm glow. One of the biggest challenges of energy conservation behavior is to raise consumer awareness of energy consuming. Vassileva et al. (2012) concluded that consumers' awareness of energy consuming can be increased by providing them with frequent information about the latest energy-saving possibilities, and giving them feedback on their energy consumption. Kuo et al. (2018) measured the electricity usage of individuals and found that new technologies and the use of digital devices can increase consumers' engagement in energy reduction and pro-environmental behaviors, such as the development of environmental knowledge and concerns, thus increasing consumers' propensity towards energy conservation (Tohănean et al., 2020). A more intense use of digital devices and applications also favors energy efficient behavior (Pelau & Acatrinei, 2019), suggesting a strong connection between digitalization and energy efficiency. Most Lithuanian respondents were aware of smart devices' environmental information, such as "sleep mode" or energy use, but deeper knowledge is needed (Harrower, 2020; Jakučionytė-Skodienė et al., 2020). Among the increased interest of practitioners on the energy efficiency of technological devices (e.g., laptops, tablets, PCs) and home appliances, mobile applications play an important part in energy saving.

1.2. Energy-efficient mobile applications

As the number of smartphones and communication devices increases yearly, the lifecycle of smartphones tends to represent a growing environmental concern, as such devices must be recycled, so that they do not harm the environment. The average lifecycle of a smartphone is about three years (Martinho et al., 2017), but due to a lack of proper understanding of the importance of recycling, consumers are often throwing them away even earlier. Not engaging in recycling behavior tends to represent a major concern for the environment, as the high penetration of mobile devices among consumers has driven the emergence of mobile applications. Mobile apps are software designed to run on mobile devices, providing users with high-quality information and services (Hsu & Lin, 2015). During the execution process, mobile apps consume the energy of smartphones (Yan et al., 2019). Traditional components, such as CPUs (Central Processing Unit) and LCDs (Liquid Crystal Display), and advanced components such as 3G/4G, WiFi, Bluetooth, and GPS consume the most energy of the smartphone (Ahmad et al., 2017; Lăzăroiu et al., 2020b).

Moreover, mobile apps with high video play resolution (e.g., Youtube, InShot, AllCast) and instant messaging applications (e.g., WeChat; Facebook Messenger) increase mobile data traffic (Yan et al., 2019). Pihkola et al. (2018) found that in Finland, due to growing data usage, network energy consumption is increasing. Wilke et al. (2013) analyzed user comments for Android applications from Google Play and found that the energy efficiency of apps is influencing user ratings, 18% of all comments being reported about energy consumption problems. In their study, negative comments about energy issues led to negative user feedback, except for gaming apps. The energy efficiency of mobile apps represents a substantial challenge, even for global software companies such as Microsoft and Google (Wilke et al., 2013). Green energy is perceived as a solution to prevent climate change (Roe et al., 2001; Ionescu, 2020); therefore the green trend has also been transferred to mobile applications. The term 'green' is often used to describe the sustainable and environmentally friendly appearance of a product, service, process, or technological development, and to its role in improving pro-environmental behavior (Barboza & Filho, 2019). Therefore, green mobile apps might motivate users to adopt a greener and more environmentally friendly lifestyle.

Heikkinen et al. (2012) found that the optimization of mobile energy consumption was a topic of concern among users, who were thus opened to receiving more information about battery status and/or energy-saving features.

2. Proposed conceptual model and hypothesis development

2.1. Energy conservation attitude and energy conservation behavior

Attitude reflects an individual opinion of a particular behavior. Oikonomou et al. (2009) found that a positive attitude towards energy saving can enhance residents' awareness of their energy consumption. Moreover, attitude towards the environment seems to be an important predictor of energy conservation behavior (Ek & Söderholm Patrik, 2010; Clement et al., 2014; Wang et al., 2014). A positive attitude represents a crucial antecedent of purchasing energy-efficient appliances (Waris & Ahmed, 2020; Waris & Hameed, 2020). Wang et al. (2021) examined the effect of personality traits on household energy conservation and found that attitude significantly influenced households' energy-saving behavioral intentions. Openness was found to have the highest positive impact on attitude. Thus, previous studies provide sufficient evidence for supporting the following hypothesis:

H_1: Energy conservation attitude has a direct and positive influence on consumers' energy conservation behavior.

2.2. Subjective norm and energy conservation behavior

Social influence is one of the most prominent factors in shifting to pro-environmental behavior (Abrahamse & Steg, 2013). Back in the 1980s, the subjective norm was already linked to energy-saving, being regarded as an important predictor of energy- saving behavior (Midden & Ritsema, 1983). Later studies confirmed the powerful impact of subjective norms on residents' energy conservation behavior (Clement et al., 2014; Wang et al., 2014). Although subjective norms exert a significant impact on the behavioral intention of purchasing energy-efficient products, attitude seems to be a stronger predictor of behavioral change (Ha & Janda, 2012). From the perspective of household energy conservation behavior, it was found that subjective norm impacts significantly on behavioral intention (Webb et al., 2013). Thus, considering these arguments, the following hypothesis is proposed:

H_2: Subjective norm exerts a direct and positive influence on consumers' energy conservation behavior.

2.3. Environmental knowledge and energy conservation behavior

Being well informed about the development of society and the ecosystem represents an essential basis for triggering pro-environmental behavior. Barber et al. (2009) claimed that knowledge is interconnected with behavior through individuals' environmental attitudes. Consumers who have greater knowledge of electricity saving methods and hold more information about energy conservation have a higher intention to participate in energy conservation behavior (Wang et al., 2011), and tend to pay more for renewable energy (Zografakis et al., 2010). Although there is evidence that environmental knowledge exhibits a direct effect on environmental behavior among students (Zsóka et al., 2013), this influence might also be indirect (Wang et al., 2014; Tan et al., 2017); moreover, knowledge can be an important indirect predictor of energy conservation (Clement et al., 2014). Paço and Lavrador (2017) compared students' energy conservation attitudes and behaviors with their level of environmental knowledge, noting no significant differences among the dimensions. Thus, while there may be disagreement on a range of results regarding the relationship between environmental knowledge and energy conservation behavior, we presume that environmental knowledge is a prerequisite for energy conservation behavior, and hypothesize that:

H_3: Environmental knowledge has a direct and positive impact on consumers' energy conservation behavior.

2.4. Collectivism and energy conservation behavior

Energy consumption represents a global problem, and therefore requires collective action to deal with it and to promote energy conservation behavior. White et al. (2019) described the phenomenon as the "challenge of collective action", in which people may act in a certain way due to the social influence of green actions, thus contributing to the increase in "collective efficacy". Considering energy conservation behavior, academics have addressed little attention to this topic. White et al. (2019) highlighted the importance of collective action in developing sustainable behavior, also calling for future research on this topic. Due to the tangibility aspect of collective action, they indicate that consumers' awareness of sustainable behavior could increase by promoting the collective consequences of causes. Therefore, the following hypothesis is formulated:

H_4: Collectivism has a direct and positive influence on consumers' energy conservation behavior.

2.5. COVID-19 and energy conservation behavior

Until the outbreak of the COVID-19 pandemic, world energy consumption was on a continuous increase (Enerdata, 2019; Collins, 2020; Valaskova et al., 2021) due to technological development, increased industrial production, and household consumption. Now however, with the various negative effects of COVID-19, new opportunities and benefits have emerged in the energy sector due to the pandemic. While the circular economy may contribute to energy reduction (Su & Urban, 2021), the pandemic has forced numerous organizations to reduce their activity, thus decreasing energy consumption (Eysenck, 2020; Soava et al., 2021). The effect of the COVID-19 pandemic has thus indirectly contributed to a reduction in pollution and to a cleaner environment. Mohideen et al. (2021) highlighted the positive impact of COVID-19 on the energy economy, enabling policymakers to develop green energy consumption strategies based on hydrogen and fuel cell technologies. Green energy seems to have been one of the most profitable investments during and since the pandemic (Ionescu, 2020; Mihajlović et al., 2021). The pandemic has also increased responsibility towards energy consumption and the environmental concerns of consumers (Dahalan et al., 2020; Lăzăroiu et al., 2020a; Smith, 2020; Valaskova et al., 2021). As the COVID-19 pandemic has changed the global economy and individual ways of living to a 'new normal', where green energy seems to have become a crucial solution to sustainable living, we hypothesize that:

H_5: COVID-19 pandemic positively influences consumers' energy conservation behavior.

2.6. Functional values and intention to use green apps

Functional values are utilitarian features of products, increasing their performance through durability, reliability, and price (Suki, 2015). Consumers' who prioritize functional values are usually task-oriented, and their decision-making is based on rationality (Picot-Coupey et al., 2021). Functional values often relate to the core characteristics of mobile devices such as ubiquity, localization, personalization, and convenience (Clarke, 2001). Mulcahy et al. (2020) considered functional value as the knowledge that incorporates both perceived usefulness and ease of use, thus displaying a significant influence on energy-saving behavior through gamified mobile apps. Based on these arguments, we exert that:

H_6: Functional values of the mobile apps have a positive impact on energy-efficient app usage intention.

2.7. Hedonic values and intention to use green apps

The core of hedonic values consists of the desire for fun and enjoyment, thus displaying a gamification value (Dastane et al., 2020). Hedonic values, such as enjoyment, fun, and pleasure impact significantly on mobile app usage of green mobile apps. For instance, the Chinese Ant Forest application encourages users in active green behavior, such as planting trees or adopting a low-carbon lifestyle. Zhang et al. (2020) measured the steady usage of this app and found that perceived enjoyment and game interaction positively influence users' satisfaction, which in turn determines its usage. Mulcahy et al. (2020) found that gamified apps positively influence consumers' energy-saving behaviors. Therefore, we hypothesized that:

H_7: Hedonic values of the mobile apps have a positive impact on energy-efficient app usage intention.

2.8. Energy conservation behavior and intention to use energy-efficient apps

Although the "Going Green" movement is gaining greater awareness among consumers and organizations, changing their behavior remains a major challenge regarding energy consumption. In managing energy reduction, transparent communication plays a major role in increasing energy awareness among individuals (Marans & Edelstein, 2010). In addition, energy awareness campaigns and energy challenges also contribute to decreased energy consumption (Kemp-Hesterman et al., 2014). Mass media still represents the most favored communication channel for triggering energy conservation behavior (Sheau-Ting et al., 2019). Literature has intensively studied the antecedents of energy conservation behavior. For instance, Paswan et al. (2017) found that hedonic values, such as enjoyment and personal beliefs in the human/nature balance increased consumers' engagement in pro-environmental behavior. Scholars have identified energy conservation behavior in various contexts, and found the factors which significantly influence consumers' energy consumption level: building regulations, environmental concerns, education, and social marketing (Ishak, 2017). Kotsopoulos et al. (2018) discovered that gamification apps can motivate employees to adopt energy conservation behavior and develop a greener working attitude. Design elements, such as progression, levels, and points can improve the daily usage of apps. According to these arguments regarding energy conservation, we hypothesize a correlation between energy conservation behavior and app usage intention:

H_8: Energy conservation behavior has a positive impact on the intention to use energy-efficient mobile applications.

Based on the literature review, we propose a conceptual model (Figure 1) which incorporates the impact of energy conservation attitude, subjective norms, environmental knowledge, collectivism, and COVID-19 on young consumers' energy conservation behavior. Moreover, the model explores the impact of energy conservation behavior, and functional and hedonic values on consumers' energy-efficient app usage intention.

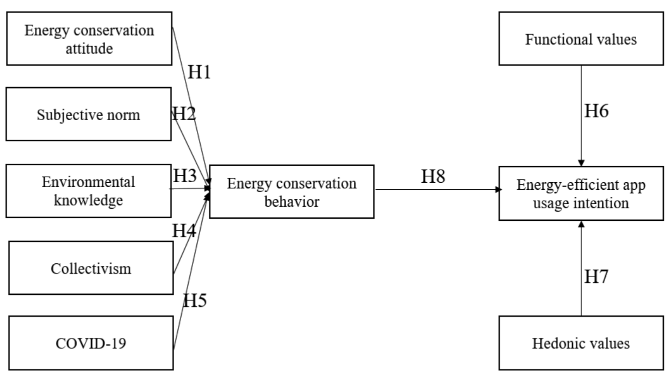

Figure 1. Conceptual model

3. Research methodology

3.1. Research design and sample

The aim of this research is to explore which factors influence consumers' willingness to use energy-efficient mobile applications. To fulfil the research scope, the present study proposes to identify the antecedents of energy conservation behavior and to examine the impact of COVID-19 on consumers' energy conservation behavior (Figure 1). In this regard, we conducted an empirical investigation among Romanian young people to highlight their pro-environmental energy conservation behavior when using apps. Consistent with the National

Renewable Energy Action Plan (NREAP), Romania exceeded the 2020's renewable energy target in 2014 (24% of final energy consumption) and intends to achieve 30.7% renewable energy consumption in 2030 (Enerdata, 2019).

To assess the impact of energy conservation behavior on energy-efficient app usage intention, and the supplementary factors (attitude, subjective norms, environmental knowledge, collectivism, COVID-19, functional and hedonic values) an online survey was conducted from November to January 2021. The target population of the survey was represented by Millennials/Gen Y (born between 1980 and 1994) and Gen Z (born between 1995 and 2002) because they are heavy smartphone users (Dabija & Băbuț, 2019; Scott et al., 2020). Table 1 presents the socio-demographics of the respondents. Approximately half of the respondents (N = 269; 45.6%) had not heard about energy-efficient apps, while the majority of those who were familiar with these apps (N = 299, 50.7%) were using energy-efficient mobile apps. Regarding consumers' mobile usage habits: most of the respondents closed those apps not being used at that moment, reduced screen brightness, and turned off the Bluetooth, GPS, and synchronization functions when they were not needed.

Table 1. Socio-demographics characteristics

Demographics (N = 590)		Frequency	Relative Frequency %	Frequency	Relative Frequency %
		Millennials (N = 149)		Gen Z (N = 441)	
Gender	Male	70	47.0	157	35.6
	Female	79	53.0	284	64.4
Education level	High School	39	26.2	60	13.7
	Bachelor's Degree	59	39.6	298	67.6
	Master's Degree and PhD	51	34.2	83	18.8
Occu-pation	Student	22	14.8	248	56.2
	Employee	103	69.1	169	38.3
	Entrepreneur	18	12.0	17	3.8
	Non-workers (unemployed/retired)	6	4.0	7	1.6
Mobile operation system	Android	104	69.8	235	53.3
	Apple	42	28.2	204	46.3
	Windows	3	2.0	2	0.5
Average duration of mobile battery	Less than 6 hours	18	12.1	47	10.7
	Between 6–7 hours	25	16.8	144	32.7
	One day	79	53.0	215	48.8
	Two days	21	14.1	30	6.8
	More than two days	21	4.0	5	1.1

3.2. Questionnaire design and measures

The questionnaire was operationalized according to previous research conducted in this field (Table 2). Some items of the scales have been adjusted to match the aim of our research. The only exception is represented by the independent variable, COVID-19, which was developed by the authors due to the newness of the situation. All items were assessed using a 5-point Likert scale, ranging from total disagreement (1) to total agreement (5).

Table 2. Conceptualization of the independent and dependent variables

Construct / Reference	Item	Measure	Loading	Cronbach's Alpha	AVE / CR
Energy conservation attitude / Tanner and Kast, 2003	ECA1	Environmental protection is important to me when making purchases.	0.840	0.781	0.695 / 0.872
	ECA2	If I can choose between energy-saving mobile applications and conventional applications, I prefer energy-saving ones.	0.803		
	ECA3	I have a favorable attitude towards purchasing an energy-saving product.	0.856		
Subjective norm / Chin et al., 2018; Thøgersen and Ölander, 2006	SN1	Persons important to me would prefer that I use energy-efficient appliances.	0.844	0.831	0.663 / 0.887
	SN2	Family and friends think it's a good idea to use energy-efficient products.	0.797		
	SN3	I feel morally obligated to buy only green/organic products.	0.820		
	SN4	I get a bad conscience if I choose conventional instead of energy-saving products.	0.796		
Environmental knowledge / Ellen et al., 1997	EKN1	I know that I buy products and packages that are environmentally safe.	0.803	0.870	0.658 / 0.906
	EKN2	I know more about recycling than others.	0.819		
	EKN3	I know how to select products and packages that reduce the amount of waste ending up in landfill.	0.837		
	EKN4	I understand the environmental phrases and symbols on the product package.	0.761		
	EKN5	I am knowledgeable about environmental issues.	0.835		
Collectivism / Kim and Choi, 2005	CLV1	I respect the majority's wish.	0.782	0.750	0.667 / 0.857
	CLV2	I respect the decisions made by my group of friends.	0.855		
	CLV3	I maintain harmony in my group.	0.812		
COVID-19 / Elaborated by the authors	COV1	During COVID-19, I installed energy-saving light bulbs in the house.	0.820	0.707	0.878 / 0.857
	COV2	During COVID-19, I consumed energy more consciously.	0.819		
	COV3	During COVID-19, I tried to save electricity.	0.881		

End of Table 2

Construct / Reference	Item	Measure	Loading	Cronbach's Alpha	AVE / CR
Energy conservation behavior / Paço and Lavrador, 2017	ECB1	I use power-saving bulbs (fluorescent lamps or light-emitting diodes (LEDs).	0.744	0.855	0.635 / 0.896
	ECB2	Most of the equipment I use has low energy consumption.	0.857		
	ECB3	It is important to me that the appliances I use have the energy efficiency class A/A+/A++/A+++.	0.787		
	ECB4	I buy products produced with less energy or other resources.	0.830		
	ECB5	I tend to pay more for environmentally friendly products.	0.760		
Functional value / Sweeney and Soutar, 2001	FUV1	Energy-efficient mobile applications have consistent quality.	0.939	0.840	0.861 / 0.925
	FUC2	Energy-efficient mobile applications have a high performance.	0.917		
Hedonic value / Iyer et al., 2018	HEV1	Because it makes me feel good about myself.	0.924	0.829	0.854 / 0.921
	HEV2	Because I can feel a personal connection with it.	0.924		
Intention to use green apps / Chin et al., 2018; Paço and Lavrador, 2017	IUG1	I will use energy-efficient mobile applications more often in future.	0.902	0.859	0.781 / 0.914
	IUG3	I will tell other persons about the energy-efficient apps.	0.905		
	IUG2	I intend to use this app because of its environmental performance.	0.842		

Notes: ECA – energy conservation attitude; SN – subjective norm; EKN – environmental knowledge; CLV – collectivism; COV – COVID-19; ECB – energy conservation behavior; FUV – functional values; HEV – hedonic values; IUG – green app usage intention; Factor loading >0.7; Cronbach's Alpha >0.7; Average variance extracted (AVE) >0.5; Composite reliability >0.7.

3.3. Data analysis

Partial least squares structural equation modelling (SmartPLS 3.0) was employed to test the proposed conceptual model in Figure 1. First, we applied confirmatory factor analyses to the measurement model to examine the reliability and validity of each construct, then a bootstrap procedure was used to test the proposed hypotheses. For the assessment of scale reliability, we tested the factor loading, Cronbach Alpha, average variance extracted (AVE), composite reliability (CR), and discriminant validity. The results (Table 2) express that all factor loadings are higher than 0.7 and AVE's are above 0.5 (Hair et al., 2010), therefore the convergent validity of the constructs is validated. Furthermore, Cronbach's alpha and CR values exceed the 0.7 criteria, suggesting the internal consistency and reliability of the scales (Hair et al., 2010; Henseler & Sarstedt, 2013). The discriminant validity (Table 3) was tested using the Heterotrait-Monotrait (HTMT) criteria. This test illustrates that all values are under 0.9 (Henseler et al., 2014), demonstrating the discriminant validity of the constructs.

Table 3. Discriminant validity

	Heterotrait-Monotrait (HTMT)								
	ECA	COV	CLV	ECB	FUV	HEV	IUG	EKN	SN
ECA									
COV	0.569								
CLV	0.298	0.183							
ECB	0.683	0.711	0.240						
FUV	0.272	0.145	0.205	0.146					
HEV	0.249	0.234	0.197	0.206	0.736				
IUG	0.341	0.236	0.245	0.227	0.743	0.758			
EKN	0.644	0.521	0.302	0.620	0.103	0.093	0.166		
SN	0.838	0.604	0.333	0.665	0.245	0.284	0.332	0.612	

Notes: ECA – energy conservation attitude; SN – subjective norm; EKN – environmental knowledge; CLV – collectivism; COV – COVID-19; ECB – energy conservation behavior; FUV – functional values; HEV – hedonic values; IUG – green app usage intention.

Furthermore, the collinearity of the outer and the inner model was tested with variance inflation factor (VIF). For the outer model, all VIF values are ranged between 1.418 and 2.462, and for inner model the highest value was disclosed for SN→ECB (2.128), suggesting no multi-collinearity issue.

4. Results and discussions

The results of the bootstrap procedure (Table 4) show that seven of the eight hypotheses were accepted, and one rejected (see Figure 2). H_1 assumed that energy conservation attitude has a positive impact on consumers' energy conservation behavior (β = 0.185; T-value = 3.836; $p < 0.001$). The more favorable the attitude towards energy conservation (e.g., preference for energy-saving products or concern for environmental protection), the more likely consumers are to engage in energy-saving activities such as using power-saving bulbs or buying products with less energy consumption. This is in line with similar research (Waris & Ahmed, 2020; Waris & Hameed, 2020); therefore H_1 can be supported. H_2 concluded that subjective norm has a significant impact on consumers' energy conservation behavior (β = 0.157; T-value = 3.384; $p < 0.001$). Family and friends' opinions, the feeling of moral obligation and social pressure positively influences respondents' pro-environmental behavior; therefore, social influence represents a positive predictor of energy conservation behavior. Similar results were also obtained by Webb et al. (2013), Clement et al. (2014) and Wang et al. (2014); thus, H_2 is accepted. In accordance with Ha and Janda (2012), attitude seems to be a stronger predictor of energy conservation behavior than subjective norms. H_3 indicated that environmental knowledge exerts a positive impact on consumers' energy conservation behavior (β = 0.204; T-value = 5.294; p < 0.001). The more knowledgeable consumers are about environmental issues, such as recycling or eco-labelling, the higher their willingness to display an energy conservation behavior. The findings confirm the studies of Wang et al. (2011) and Zsóka et al. (2013), but are in contrast to those of Wang et al. (2014); Tan et al. (2017), and Paço and Lavrador (2017).

H_4 presumed that collectivism has a significant impact on consumers' energy conservation behavior. The results indicate an insignificant relationship between collectivism and energy conservation behavior (β = 0.012; T-value = 0.389; p > 0.05); therefore H_4 is rejected, this being contrary to White et al. (2019). H_5 suggested that the COVID-19 pandemic could contribute to consumers' energy conservation behavior (β = 0.345; T-value = 9.794; p < 0.001). Therefore, consumers seemed to have a better awareness of energy consumption during the pandemic, contributing to their energy conservation behavior; thus, H_5 is supported. Previous studies (Dahalan et al., 2020; Ionescu, 2021a; Mohideen et al., 2021; Su & Urban, 2021) revealed that COVID-19 might give new opportunities for the environment and energy sector, our results also implying that COVID-19 positively contributes to consumers' energy-saving behavior. H_6 indicated that functional values such as the consistent quality and performance of energy-efficient mobile apps have a positive impact on consumers' willingness to use these types of apps; thus H_6 is accepted (β = 0.382; T-value = 5.270; p < 0.001). Mulcahy et al. (2020) came to similar conclusions. Moreover, the findings indicate that the hedonic values of the app also contribute to consumers' usage intention (β = 0.397; T-value = 5.808; p < 0.001), therefore H_7 can be supported. Several researchers demonstrated the positive impact of hedonic values on green app usage intention (Zhang et al., 2020; Mulcahy et al., 2020); thus our results are consistent with them. H_8 suggested that energy conservation behavior has a positive impact on energy-efficient app usage intention (β = 0.079; T-value = 2.660; p < 0.01). Therefore, consumers are more likely to use energy-efficient apps and to recommend the app to their peers when they have greater energy conservation behavior,

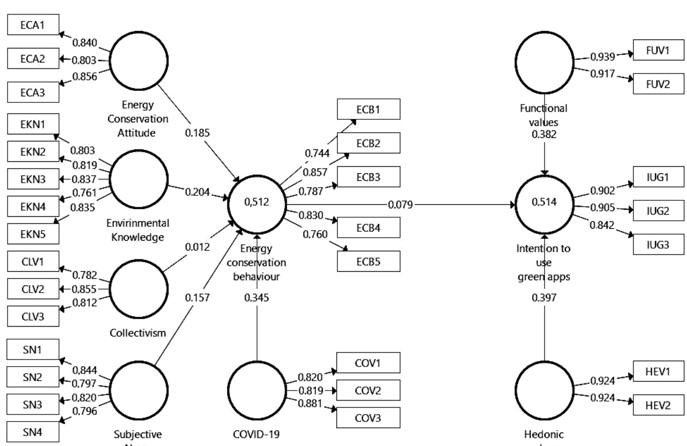

Figure 2. Structural model

thus H_8 is supported. Similar conclusions were also assessed by Kotsopoulos et al. (2018).

Considering the squared root mean residual (SRMR) value, SRMR = 0.052, which is below 0.08, the fit statistics predicts an acceptable model. While Yuriev et al. (2020) considered that the average percentage of explained variance for pro-environmental behavior is 37.2% in the present research, energy conservation attitude, subjective norms, environmental knowledge, collectivism, and COVID-19 pandemic are responsible for 51.2% of the variance of energy conservation behavior ($R^2 = 0.512$), therefore exceeding the average R^2. Moreover, energy conservation behavior, and functional and hedonic values explain 51.4% of the variance of energy-efficient app usage intention ($R^2 = 0.514$), suggesting a moderate predicting power of the structural model.

Table 4. The path coefficients of the structural equation model

Paths	Path Coefficients	Standard Deviation	T-Value	P values	Hypotheses
ECA→ECB	0.185	0.048	3.836***	0.000	H_1: Supported
SN→ECB	0.157	0.046	3.384***	0.001	H_2: Supported
EKN→ECB	0.204	0.039	5.294***	0.000	H_3: Supported
CLV→ECB	0.012	0.032	0.389$^{n.s.}$	0.697	H_4: Not supported
COV→ECB	0.345	0.035	9.794***	0.000	H_5: Supported
FUV→IUG	0.382	0.072	5.270***	0.000	H_6: Supported
HEV→IUG	0.397	0.068	5.808***	0.000	H_7: Supported
ECB→IUG	0.079	0.030	2.660**	0.008	H_8: Supported

Note: *p < 0.05; **p < 0.01; ***p < 0.001; n.s.: no significance; ECA – energy conservation attitude; SN – subjective norm; EKN – environmental knowledge; CLV – collectivism; COV – COVID-19; ECB – energy conservation behavior; FUV – functional values; HEV – hedonic values; IUG – green app usage intention.

Wang et al. (2011) found that people with greater knowledge of electricity saving methods are more willing to participate in energy conservation behavior, and display an increased willingness to pay more for renewable energy (Zografakis et al., 2010; Brătucu et al., 2019), while Wang et al. (2014) or Tan et al. (2017) found no direct influence. Our findings highlight the importance of environmental knowledge in displaying energy conservation behavior; therefore we support the findings of Wang et al. (2011) and Zsóka et al. (2013) who demonstrated the positive and direct impact of knowledge on environmental behavior among young people in an emerging market. The energy conservation literature also suggests that collectivism forms a research gap, as highlighted by White et al. (2019) who claimed that collective action remains "an open question for future research" (p. 34). We answer this call to action by examining the impact of collectivism on consumers' energy conservation behavior, although no significant impact was found. Moreover, the innovation of the present research is also given by introducing the COVID-19 construct, as the pandemic has radically and profoundly changed our lives, desires, expectations, and habits (Nemțeanu & Dabija, 2020). Due to the new situation, individuals might have developed environmental awareness, thus being more concerned about and supporting investments in the energy sector (Mihajlović et al., 2021;

Mohideen et al., 2021), but also understanding the need for more environmental awareness towards energy consumption (Dahalan et al., 2020). Our results highlight the positive impact of COVID-19 on consumers' energy consumption awareness. The social distancing imposed by COVID-19 has forced consumers to spend more time at home (Lăzăroiu et al., 2020a; Ionescu, 2021a; Valaskova et al., 2021). One of the biggest disadvantages of working from home is having to use one's own energy resources. In comparison to previous times, where the company paid for the energy used for lightning, computers and so on, all these costs shifted to the consumer. Therefor energy consumption in many households increased due to working from home, which made consumers more aware of existing energy costs (Pflugmann & De Blasio, 2020; Ionescu, 2021b). This has triggered the importance of energy efficient actions and energy-saving behavior. Energy conservation attitudes and subjective norms as dimensions of the TPB significantly influence consumers' energy conservation behavior, these findings being in line with previous research (Clement et al., 2014; Wang et al., 2014; Waris & Ahmed, 2020; Waris & Hameed, 2020; Ionescu, 2021b). Therefore, attitude, subjective norm, knowledge, and COVID-19 are strong predictors of consumers' energy conservation behavior, while collectivism is insignificant. Our empirical findings also support the work of Mulcahy et al. (2020), who suggested that gamified apps and functional value of mobile apps can contribute to energy-saving behavior. When looking at the value of the coefficients, it can be observed that the utilitarian and hedonic values of mobile apps usage is higher in comparison to energy conservation behavior. Therefore, it is expected that utilitarian and hedonic values are better predictors of the use of energy efficiency mobile applications in comparison to energy-friendly behavior. Consumers who have strong ecological beliefs already demonstrate energy-friendly behavior, as proven in this research. The results of the research reveal another interesting group of heavy users of mobile applications, who might become interested in increasing their energy efficiency, by starting to use energy efficient mobile applications. The use of mobile applications and different AI systems for measuring energy efficiency could stimulate consumers to increase their pro-environmental behavior (Scott et al., 2020). Even though these users will not have as their main goal the protection of the environment, but to increase their performance via the energy efficiency application, it might be a way of changing behavior. In future research, we intend to empirically test the impact of the extrinsic motivation of performance in energy efficiency application on increasing energy efficient behavior and on the intrinsic motivation of protecting the environment.

Conclusions

The present study examined a model of energy-efficient apps by incorporating the variables of TPB and extending them with other independent variables disclosed in the literature. The novelty of the research consists in examining the usage intention of energy-efficient apps from a consumer behavioral perspective. We also considered the two most influential motivations for using an app, the hedonic and functional values, while also exploring the impact of energy-saving behavior on usage intention. Furthermore, we examined the antecedents of energy conservation behavior by merging the elements of TPB, energy conservation attitude, and subjective norms, with supplementary factors previously considered controversial in the literature: environmental knowledge, collectivism, and COVID-19. Environmental knowledge is considered one of the most studied factors on consumers' pro-environmental behavior.

The research also provides some useful implications for marketers, policymakers, and software developers. Firstly, marketers need to elaborate well-defined communication to raise awareness of energy conservation, because although many consumers display a positive attitude towards energy saving, they are less aware of their energy consumption inclination, and of the possible consequences, e.g. half of the respondents did not monitor their energy, water, or natural gas consumption; did not turn off or unplug electrical appliances when not in use; did not use rechargeable batteries; left their smartphones charging all night; and these are only a few of the bad habits which strongly influence the environment. Even if consumers are knowledgeable about environmental issues, they do not have sufficient information about energy problems. Considering these facts, and that such consumers are strongly influenced by their peers, we recommend the promotion of energy efficient apps through influencers. Hedonic values appear as strong predictors of green app usage intention; therefore, we suggest that developers design these apps with gamified elements, which give more pleasure, enjoyment, and fun during the usage journey, linked with high performance and quality.

Amongst the limitations, we can mention the fact that the target population consisted only of members of Millennials/Gen Y and Zers, with no members of previous generations, such as Gen X or Baby Boomers being considered. As people grow older, their energy conservation behaviors, pro-environmental attitudes, and recycling inclination, and/or patterns might differ. Another limitation lies in not comparing apps from different retailers and/or companies with both physical and online stores.

Future research could rely on a generational approach, thus exploring possible differences and similarities among generations in developed versus emerging markets. As the research was conducted in an emerging market (Romania), we suggest replication of the study in other emerging markets, and/or conducting cross-cultural and/or cross-national investigations. Future studies could also consider other constructs that impact on mobile app usage, such as altruistic values, past behavior, and environmental awareness, or could employ a comparative approach towards shopping, and gaming versus entertainment apps. It would also be relevant to investigate the degree to which consumers only use apps to inform themselves about product offers, with the actual buying decision taken either in the physical store or in the online store. Research could also emphasize the degree to which consumers tend to mix their online and offline behavior for gaining information, making product comparisons, and buying, switching their behavior from apps to online websites and/or offline stores, if, for instance, the app does not work properly.

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