UNDERSTANDING THE HUMAN DIMENSIONS OF THE INTENTION TO USE RENEWABLE ENERGY IN HUNGARY – APPLYING AN EXTENDED MODEL OF THEORY OF PLANNED BEHAVIOUR

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Abstract
The past year has brought drastic changes to the European energy market. With recent dramatic increases in energy prices, it is of the utmost importance that residential users significantly increase their use of renewable energy. The aim of our study is to understand the complex psychological background of the intention to use renewable energy by applying the Theory of Planned Behaviour (TPB). We extended the original TPB to include environmental concerns. To collect data, an online survey was conducted in Hungary in November 2022. Structural equation modelling (SEM) was used to analyse data from 400 residential users. The resulting model suggests that subjective norms have the greatest direct influence on intention to use renewable energy; however, attitudes formed by environmental concerns are also important influencing factors. Therefore, campaigns to promote the use of renewable energy should focus on the social acceptance of this behaviour and educate target groups about the connection between the energy problem and the challenges of climate change.

Keywords: renewable energy use, theory of planned behaviour, attitudes, behavioural intention, Hungary

JEL Classification: D12, D91, Q40, Q50

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Introduction

The need to switch to and promote renewable energy sources in the European Union has never been more urgent for several reasons. The most important are climate change and the reduction of energy dependence on fossil fuels, especially oil and gas imports from Russia due to the armed conflict between Russia and Ukraine.

Human-induced climate change is the largest and most widespread threat to the natural environment and societies, affecting the poorest countries the most (United Nations, 2022). According to the World Economic Forum's Global Risks Report 2022, three environmental risks - failures to address climate change, extreme weather, and biodiversity loss – are ranked first, second, and third on a list of the top ten global risks for the next decade.

The war between Russia and Ukraine has caused energy prices in the European Union to skyrocket, significantly worsening the economic outlook and causing inflation to rise dramatically and immediately become a major global concern (IPSOS, 2022). Inflation is now the biggest global concern. 40% of the respondents said that it is one of the most important issues facing their country today. Climate change, however, remains a top concern, ranking seventh on the IPSOS list of 18 concerns and cited as a concern by an average of 16%.

Electricity and gas prices in Europe, which are of particular concern in the context of our survey, have soared, partly due to a surge in energy demand in the post-pandemic period. However, this was exacerbated by Russia's invasion of Ukraine in early 2022. Summer heat waves, which also increased electricity demand, and uncertainty about future gas supplies caused prices to spike, leading to record prices in most EU countries in August 2022 (Figure no. 1). Since electricity tariffs are highly dependent on the price of gas and coal, the sharp increase in gas and coal prices significantly increased electricity costs. According to Statista (2023), risks related to the future Russian gas supply and uncertainties associated with ending dependence on Russian energy sources were the key driving factors behind the increase in gas prices in 2022.

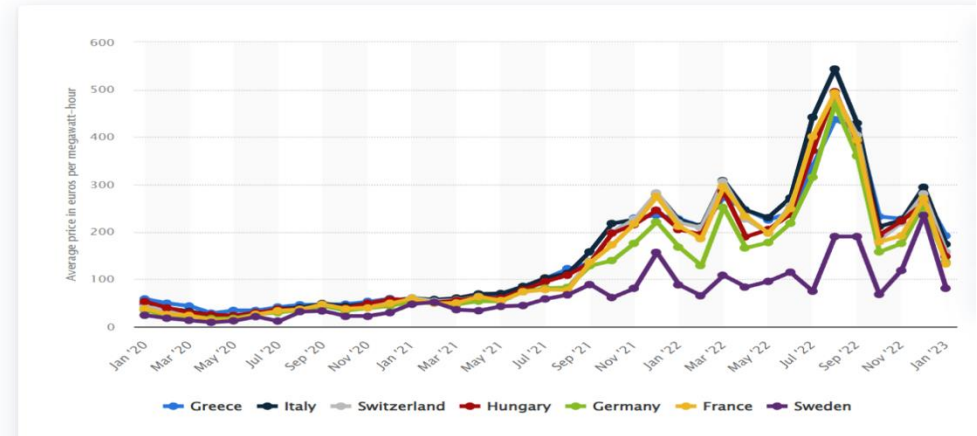

Figure no. 1. Average monthly electricity wholesale prices in selected countries in the European Union (EU) from January 2020 to January 2023 (in Euros per megawatt-hour)
Source: Statista, 2023

Electricity prices for residential end users are traditionally very high in the EU countries due to the fact that they are not rich in fossil fuels. In June 2022, the highest residential electricity prices worldwide were recorded in Denmark ($0.53 per kWh) and Germany ($0.52 per kWh). It should be noted that taxes account for a significant share of electricity prices in these countries. In contrast, electricity prices are significantly lower in countries with significant crude oil and natural gas production, for example, in Qatar it is only $0.03 per kWh. (Statista, 2023)

However, the distribution of electricity prices in Europe has always been uneven; for example, Hungarian and Dutch households pay only a fraction of the Danish price (Figure no. 2). According to Eurostat (2022), the highest electricity prices in the first half of 2022 were recorded in Denmark (€0.46 per kWh), Belgium (€0.34 EUR per kWh) and Germany (€0.33 per kWh), whereas the lowest were recorded in the Netherlands (€0.06 per kWh), Hungary (€0.09 per kWh), and Bulgaria (€0.11 per kWh).

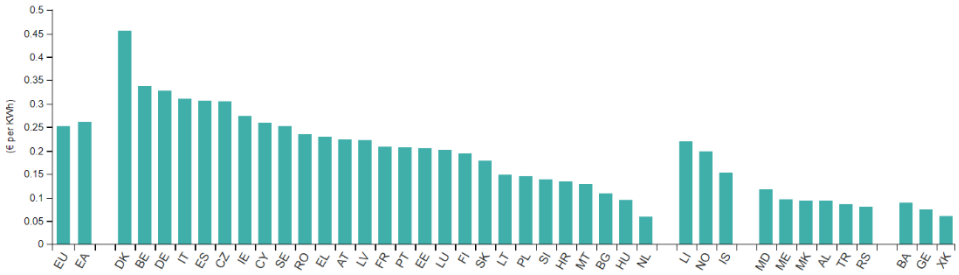

Figure no. 2. Electricity prices including taxes for household consumers
Source: Eurostat, 2022

In response to the difficulties and turmoil on the global energy market, the European Commission launched the REPowerEU plan, which aims to increase energy savings, accelerate the transition to clean energy, and diversify the EU's energy supply (European Commission, 2022a). Among other things, the Commission proposes to increase the renewable energy headline target for 2030 from 40% to 45% as part of the "Fit for 55" package (European Commission, 2021). In addition, the EU's Solar Energy Strategy has been launched, with the aim of doubling solar photovoltaic (PV) capacity by 2025 and installing 600 GW by 2030 (European Commission, 2022b). The Solar Roofs Initiative aims to promote the installation of solar panels on new public and commercial buildings, as well as on new residential buildings. It intends to double the uptake of heat pumps and integrate geothermal and solar energy into modernised district and municipal heating systems, shortening and simplifying licensing procedures. The key instrument to achieve all these goals is the Recovery and Resilience Facility (European Commission, 2023), a central instrument of the REPowerEU Plan to make European societies more sustainable and to promote and facilitate their digital transition.

Understanding and modelling renewable energy use behaviour, including the main drivers of replacing non-renewables with renewable energy and reducing fossil fuel consumption, is therefore of particular importance. There are several papers that address the drivers of renewable energy consumption at the macro (country) level (Uzar, 2020; Camacho Ballesta, Da Silva Almeida and Rodríguez, 2022; Hao, 2023). However, to our knowledge, no study has been conducted to analyse household renewable energy use behaviour of residential users by applying Ajzen's (1991) Theory of Planned Behaviour (TPB) and structural equation

modelling (SEM). Therefore, this study aims to fill this research gap and contribute to provide answers to the challenges of the new energy problems in the European Union by investigating the behaviour of residential renewable energy users in Hungary. It also proposes an integrated theoretical framework of renewable energy use behaviour of residential users. Research findings can be used in campaigns to promote the use of renewable energy, e.g., to increase the number of solar panels installed in residential areas.

Regarding the theoretical positioning of this research, we can state that our research approach is multidisciplinary. It aims to answer questions related to energy science, management, and sustainability by using the theoretical background of psychology and behavioural science.

This paper is organised as follows. First, the theoretical background for the study is presented, including the Theory of Planned Behaviour, which leads to the hypotheses and the theoretical model of the intention to use renewable energy. The following chapter covers the methodology, including the research design and the sample. It then presents the model tests, the results of the SEM, and the main findings. The paper concludes with a discussion of the results, implications for management and science, limitations, and a further research direction.

1. Literature review

1.1. Drivers of renewable energy use

Several drivers of renewable energy use by individuals can be identified, including legal restrictions, public awareness, and the impact of high energy prices. In Germany, high electricity prices and the world's first Renewable Energy Sources Act (EEG: Erneuerbare-Energien-Gesetz), which came into force in 2000, and its predecessor, the Electricity Feed Act (1991), have led to greater use of renewable energy, particularly wind and solar power (Jacobsson and Lauber, 2006). Soaring energy prices encourage energy conservation and investment in renewable energy (Ari et al., 2022). Public awareness is not sufficient to encourage a shift to renewable energy consumption. In contrast, strong policies have a positive direct and indirect effect on renewable energy consumption, and education is an important support that has positive cross-cutting effects on different drivers (Marra and Colantonio, 2021). The beneficial effect of social factors, including education, and the negative effect of economic factors on REC was confirmed by Camacho Ballesta, Da Silva Almeida and Rodríguez (2022).

Consumer intention to use renewable energy has also been studied. Sardianou and Genoudi (2013) examined the factors that determine consumers' intention to adopt renewable energy sources (RES) in the residential sector and found that the tax deduction is the most effective incentive for the adoption of renewable energy in the residential sector, followed by energy subsidies and doubling the price of conventional energy sources. Consumers' intention to adopt RES is strongly influenced by the perceived maintenance costs of renewable energy.

Oosthuizen, Inglesi-Lotz and Thopil (2022) examined the impact of increasing renewable electricity share on retail electricity prices for 34-OECD countries and found a positive and statistically significant influence of the increased share of renewable energy in the energy mix on retail electricity prices. Therefore, an increase in the share of renewable energy use among residential users would ultimately have a positive effect on retail electricity prices.

1.2. Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (Ajzen, 1991) - an extension of the Theory of Reasonable Action (Fishbein and Ajzen, 1977, 1980) with 'Perceived Behavioural Control' - helps to understand the intended and actual behaviour of individuals (Figure no. 3). This well-established model with strong predictive power can be used to understand how to change a specific behaviour. It is widely used to measure pro-environmental behaviour (Ates, 2020; Gansser and Reich, 2023) and energy-saving behaviour (Wang et al., 2018). The TPB consists of three key components: Attitude towards the Behaviour, Subjective Norms and Perceived Behavioural Control.

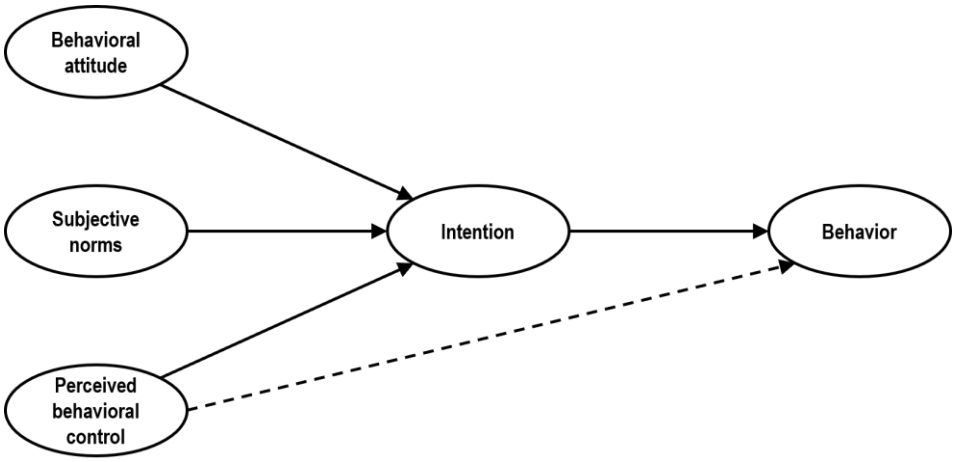

Figure no. 3. Theory of Planned Behaviour
Source: Ajzen, 1991

1.2.1. Attitude

Attitude is a relatively permanent evaluation of the attitude object, which can be a person, a product, or a social group (Albarracin, Johnson and Zanna, 2014). In TPB, attitude refers to the overall judgement and assessment of a behaviour with its expected outcome (Ajzen, 1991). Therefore, the behavioural intention - the intention to perform a specific behaviour – is determined by perceived attitudes. The results of a research conducted in a southern Italian region that has intensively promoted the adoption of renewable and energy-saving technologies show that attitude is the main determinant of households' intention to adopt and pay for Energy Efficiency Measures (Prete et al., 2017). Strazzera and Statzu (2017) also suggested the importance of attitude for the public acceptance of Photovoltaic (PV) and Building Integrated Photovoltaic (BIPV) technologies. Qalati et al. (2022) found that attitude significantly influences households' intention to save energy. If someone has a positive attitude towards the environment, they are more likely to prefer renewable energy (Lee, 2009). Therefore, it is hypothesised that:

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

1.2.2. Subjective Norms

Subjective norms refer to the support of those we value: the influence of important people and perceived social pressure from the social environment (Jhangiani and Tarry, 2022). Subjective norms are determined by someone's normative beliefs and motivation to comply (Trafimow et al., 2010). Normative beliefs refer to what a person thinks other people expect them to do (Lambert, 2021). Prete et al. (2017) found that subjective norms have positive effects on the intention to implement energy efficiency measures to decrease household energy consumption. Subjective norms significantly and positively determine the intention to use renewable energy (Liobikienė, Dagiliūtė and Juknys, 2021). Photovoltaic systems installed in the dwellings of friends, relatives and neighbours' dwellings, or in public buildings increase people's willingness to invest in and use renewable energy (Strazzera and Statzu, 2017). Subjective norms have an impact on energy saving behaviour (Qalati et al., 2022). A household's energy saving intention is strongly influenced by those we value (Xu, Hwang and Lu, 2021). Therefore, subjective norms are expected to influence the end-users' behavioural intentions to use renewable energy. Based on this, we proposed the following hypothesis:

H2: Subjective norms will positively influence the behavioural intention to use renewable energy.

1.2.3. Perceived Behavioural Control

Perceived Behavioural Control is the extent to which people believe they can actually perform the behaviour (Jhangiani and Tarry, 2022). It is related to an individual's perception of the difficulty or the ease of the change of behaviour (Ajzen, 1991). More available resources and higher confidence will lead to higher Perceived Behavioural Control (Ajzen, 1985). According to Abrahamse (2019), the intention to reduce energy consumption is related to perceived behavioural control and the attitude toward energy conservation. When people feel that they have more control over their energy saving behaviour, and have a more positive attitude toward saving energy, they will have a stronger intention to save energy. Perceived behavioural control (PBC) and households' intention to adopt Energy Efficiency Measures and their willingness to pay for them are positively correlated (Prete et al., 2017). Perceived Behavioural Control, along with awareness, relative advantage, and cost reduction, has a significant impact on the intention to adopt small-scale renewable energy (Alam et al., 2014). Perceived Behavioural Control is a strong influencing factor for energy saving intentions (Qalati et al., 2022). Therefore, we developed the following hypothesis:

H3: Perceived Behavioural Control will positively influence behavioural intention to use renewable energy.

1.2.4. Environmental concern

Since there were some critics on the narrow view of the Theory of Planned Behaviour, and even Ajzen (1991) has suggested that the Theory of Planned Behaviour can also incorporate external predictors, we have added a new component to the original TPB, namely the concern for environmental being proposed and adopted by Prete et al. (2017). In their study, they used an extended version of the Theory of Planned Behaviour to examine the antecedents of households' intention to adopt and pay for residential energy efficiency measures to effectively reduce household energy consumption. They found that environmental concern has a positive effect on the intention to adopt and pay for Energy Efficiency Measures.

Previous studies have also suggested the use of environmental concern in the Theory of Planned Behaviour. According to Hartmann and Apaolaza-Ibáñez (2012), environmental concerns have a positive influence on consumers' attitudes and willingness to buy energy-saving branded products. Residents with higher environmental concern, positive environmental values, and greater environmental knowledge are more likely to exhibit energy consumption behaviours, attitudes, and habits that would lead to energy saving measures in their households (Pothitou, Hanna and Chalvatzis, 2016). Environmental concern indirectly contributes to the intention to use renewable energy through the attitude toward renewable energy (Liobikienė, Dagiliūtė and Juknys, 2021). According to Bamberg (2003), environmental concern is an important indirect determinant of pro-environmental behaviour. Some researchers consider environmental concern as a predisposition for general attitude (Stern and Dietz, 1994; Schultz et al., 2004).

Therefore, we developed the following hypothesis:

H4: Environmental concern will indirectly influence the behavioural intention to use renewable energy.

Figure no 4. shows the theoretical model of intention to use renewable energy, including the hypotheses, which we developed based on the extended version of the Theory of Planned Behaviour.

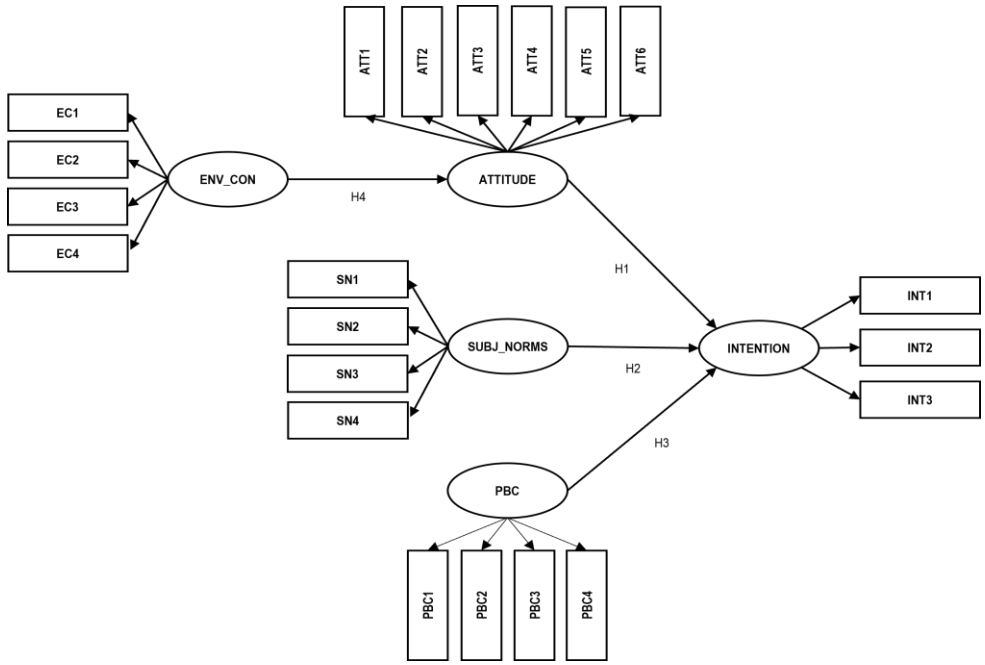

Figure no. 4. Theoretical model of the intention to use renewable energy

2. Research methodology and sample

2.1. Research methodology

The measurement constructs and items presented in Table no. 1 were developed based on the literature review and using the extended version of the Theory of Planned Behaviour. The variables of the measurement item were adapted from four different sources: 1: Qalati et al. (2022); 2: Alam et al. (2014); 3: Liobikienė, Dagiliūtė and Juknys, 2021 and 4: Prete et al. (2017). The rest of the measurement items were developed by the authors. Items marked with asterisk (*) were modified to be suitable for measuring renewable energy use.

For data collection, we used a questionnaire consisting of 23 variables related to renewable energy use. Additionally, nine demographic variables – gender, age, county, type of settlement, education, occupation, marital status, number of children, and subjective financial status - were also included in the survey. All measurement items listed in Table no. 1 were rated on a ten-point Likert-scale ranging from "strongly disagree" (1) to "strongly agree" (10).

Table no. 1. Constructs and measurement instruments

Constructs	Measurement items	Code	Source
Environmental concern	I care about climate change	EC1	3
	I care about the energy problem	EC2	own
	I'm concerned about the environment	EC3	own
	It's important for me to keep the world liveable for future generations	EC4	own
Attitude to renewable energy	The use of renewable energy enhances energy independence	ATT1	3
	Renewable energy will decrease air pollution and carbon footprint	ATT2	2
	Renewable energy contributes to sustainability	ATT3	own
	Renewable energy contributes to reduction of energy consumption	ATT4	4
	Renewable energy contributes to better quality of life	ATT5	4
	Renewable energy is valuable to alleviate energy shortage issues	ATT6	1
	Using renewable energy is trendy.	ATT7	own
	Using renewable energy is a good feeling.	ATT8	own
Subjective norms	Others (friends, neighbours, colleagues) expect me to use renewable energy	SN1	own
	It is my own decision, or my family's decision to use renewable energy	SN2	own
	People using renewable energy are more accepted in the society.	SN3	own
	It is my moral obligation to use renewable energy	SN4	1
Intention to use renewable energy	I intend to use more renewable energy	INT1	3
	I intend to have a renewable energy system (solar panel, geothermic system, wind turbine, etc.) installed at home	INT2	own
	I intend to completely give up using non-renewable energy (gas)	INT3	own
	It is easy to operate renewable energy systems (PVS)	INT4	2
Perceived behavioural control	It is easy for me to become skilful at using renewable energy apps (understand the data, graphs)	PBC1	own
	I'm good at using modern technologies and mobile apps	PBC2	own
	I have the resources, knowledge and ability to use renewable energy	PBC3	2

Source: adapted from Alam et al., 2014; Prete et al., 2017; Liobikienė, Dagiliūtė and Juknys, 2021; Qalati et al., 2022; own development and addition of the authors

For data collection, we conducted an online survey using Google Forms in Hungary in November and December 2022. We defined only one eligibility criteria for participation in this study: the age of the respondents had to be older than 18 years. In order to reach the largest possible number of respondents, we used the convenience sampling method. We migrated data from Google Forms into MS Excel, SPSS 28 and AMOS and checked for coding accuracy. The database was complete and contained no missing data. We used SPSS to conduct statistical analyses and AMOS to test the hypotheses of the model using structural equation modelling (SEM).

2.2. Data collection and sample

According to Marsh, Balla, and MacDonald (1988), a sample size of 200 is an appropriate minimum for SEM in AMOS. Schumacker and Lomax (2010) suggested a minimum of 10-20 subjects per parameter estimate in the model. Therefore, the ideal sample size is between 380 and 760, given the number of parameters estimated in the initial model (50). The actual sample size of 400 respondents falls into this category, implying a sampling error of 4.9% at the 95% confidence level.

Of the 400 respondents, 56.0% are female and 44.0% are male. The average age is 40.9 years. 65.5% of the respondents have a university degree, 33.5% have a secondary school degree, and 1.0% have a primary school degree. Most respondents live in county seats (48.5%), the rest in other cities and towns (39.5%), villages (8.0%) and in the capital (4.0%), meaning that 92% of the respondents live in an urban environment, while 8% live in a rural environment. This non-representative sample suggests that the results of our survey are most relevant to middle-aged urban residents with tertiary education.

3. Results and discussion

The initial model (Figure no. 4) did not fit the current data (CMIN/DF=2.154; p=.00; GFI=.707; CFI=.719; RMSEA=.107; HOELTER 0.5=55), so we rejected it without interpreting any parameter estimates. Therefore, it was necessary to respecify the initial model to achieve a better-fitting model, the nested model. We used the alternative model approach during the respecification process (Malkanthie, 2015). As proposed by Mueller and Hancock (2008), we developed several modified models, and selected the one with the best fit to the data (Figure no. 5) from the theoretically justifiable models. As suggested by Malkanthie (2015), we dropped variables with factor loadings below |0.7| in the Principal Component Analysis (PCA). Figure no. 5 shows that in the nested model, environmental concern is measured by two variables (EC1 and EC2), attitude toward renewable energy by three variables (ATT1, ATT3, and ATT6), and subjective norms are measured by two variables (SN1 and SN3). The intention to use renewable energy is composed of three variables (INT1, INT2, and INT3).

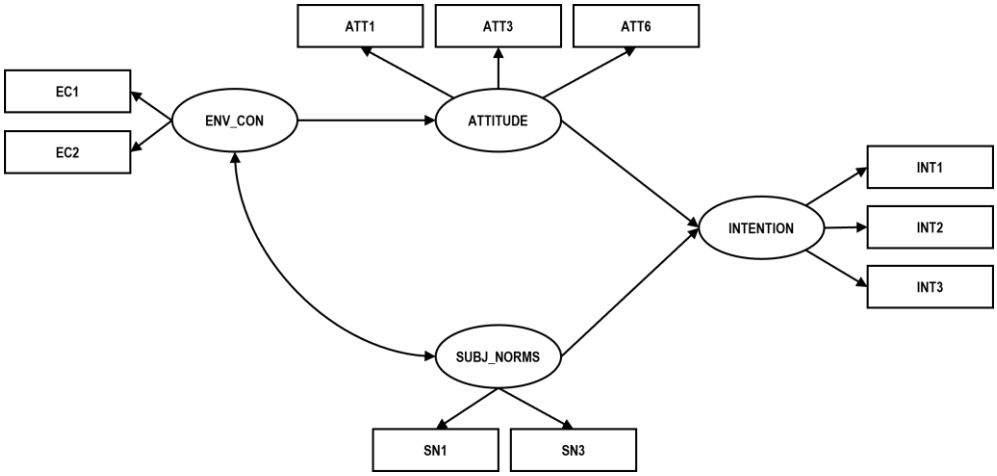

Figure no. 5. The nested model

3.1. Validity

We checked the convergent and discriminant validity of the nested model. Fornell-Larcker's (1981) criterion for convergent validity suggests that Average Variance Extracted (AVE) should be greater than 0.5. Hair et al. (1998) proposed that AVE should be greater than 0.5, the standardised factor loading on all items should be above 0.5, and the composite reliability (CR) should be above 0.7. In the nested model, all of the above-mentioned criteria were met (Table no. 2). The AVE values were also well above the threshold level (AVE (EC)=0.55; AVE (ATT)=0.66, AVE (SN)=0.63 and AVE (INT)=0.55), and all CR values exceeded 0.7 (CR (EC)=0.71; CR (ATT)=0.85, CR (SN)=0.77 and CR (INT)=0.79).

Table no. 2. Summary of means, standard deviations, validity and reliability measures

Construct	Measurement Instrument	Mean	STD	Loa-ding	α	AVE	CR
Environmental concern	EC1. I care about climate change	8.33	1.99	0.74	0.73	0.55	0.71
	EC2. I care about the energy problem	8.29	1.94	0.75			
Attitude to renewable energy	ATT1. The use of renewable energy enhances the energy independency	8.39	1.94	0.79	0.84	0.66	0.85
	ATT3. Renewable energy contributes to sustainability	8.71	1.77	0.88			
	ATT6. Renewable energy is valuable to alleviate energy shortage issues	8.39	2.11	0.76			
Subjective norms	SN1. Others (friends, neighbours, colleagues) expect me to use renewable energy	3.01	2.50	0.84	0.80	0.63	0.77

Construct	Measurement Instrument	Mean	STD	Loa-ding	α	AVE	CR
	SN3. People using renewable energy are more accepted in the society	6.42	3.13	0.74			
Intention to use renewable energy	INT1. I intend to use more renewable energy	8.11	2.21	0.74	0.73	0.55	0.79
	INT2. I intend to have a renewable energy system (solar panel, geothermic system, wind turbine, etc.) installed at home	7.49	2.62	0.77			
	INT3. I intend to completely give up using non-renewable energy (gas)	6.20	3.07	0.72			

Notes: STD=Standard Deviation, α = Cronbach's alpha, AVE= Average Variance Extracted, CR= Composite Reliability, N=400

Since the lack of correlations above 0.85, which is the threshold for limit of poor discriminant validity (David, 1998), the nested model has adequate discriminant validity (ATT*INT=0.42; INT*EC=0.39; SN*INT=0.69; ATT*EC=0.45; ATT*SN=0.08 and SN*EC=0.41).

3.2. Reliability

We used three reliability tests – Cronbach's alpha (α), the Average Variance Extracted index (AVE), and the Composite Reliability (CR) – to examine the accuracy and consistency of the nested model. The measurement model is acceptable if all estimates are significant and α > 0.5 or 0.7 (optimal); AVEs for all constructs are above 0.5 (Forner and Larcker, 1981); and the CRs for all constructs are above 0.7 (Malkanthie, 2015). Table no. 2 shows that the Cronbach's alphas of all constructs were 0.73 or higher, and the AVE values were also higher than 0.55, and the CRs were above 0.71; therefore, the reliability of the measurement model is optimal.

3.3. Model fit

We tested absolute and relative model fit. Each absolute measure was significant and indicated a good fit (Chi square=38.41 (DF=31); Probability level=0.17; CMIN/DF=1.24; GFI=0.93; AGFI=0.88; RMSEA=0.05; SRMR=0.06). We used TLI/NNFI, GFI, AGFI, NFI, IFI, CFI to test the relative model fit (TLI/NNFI=0.96; GFI=0.93; AGFI=0.88; NFI=0.89; IFI=0.98 and CFI=0.97) and found them to be acceptable or good. Values above 0.9 represent an acceptable fit, and values above 0.95 refer to a good fit according to Bentler and Bonnet (1980). The results of the absolute and relative model fit tests confirm that the structural nested model is acceptable and suitable for the analysis and interpretation of the parameter estimates.

3.4. Hypothesis testing and estimates

To understand the human dimensions of the intention to use renewable energy, we tested the hypotheses using the nested structural model. Table no. 3 summarises the results of the hypothesis tests and the direct, indirect, and total effects measured in the model.

Table no. 3. Direct, indirect, total effects and hypothesis testing

Hypothesis	Relationship	P	St. direct eff.	St. indirect eff.	St. total eff.	Result
H1	INT ← ATT	0.005	0.34	0.000	0.34	accepted
H2	INT ← SN	0.003	0.65	0.000	0.65	accepted
H3	INT ← PBC	rejected				
H4	ATT ← EC	0.005	0.44	0.000	0.44	accepted

We calculated gamma estimates from the exogenous construct to the endogenous construct, and beta estimates between two endogenous constructs. Figure no. 6 shows the standardised estimates, loadings, and residuals regarding the relationships between the constructs and the observed indicators. If the presence of a statistically significant relationship in the predicted direction was confirmed, we accepted the hypothesis.

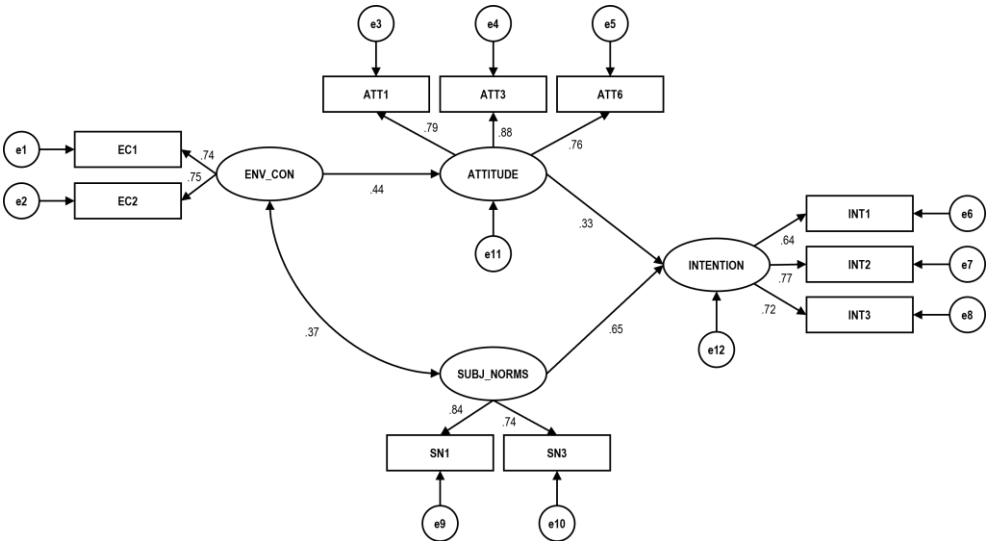

Figure no. 6. Parameter estimates of the nested model

Our research findings suggest that residential users' intention to use renewable energy is directly and positively influenced by subjective norms and attitudes, and indirectly influenced by environmental concern through renewable energy attitudes (Figure no. 6).

Attitudes have a positive effect on the use of renewable energy. The more we believe that renewable energy contributes to sustainability, that using renewable energy increases energy independence, and that renewable energy is a potential solution to energy shortages, the stronger our intention to use renewable energy will be. A positive attitude toward renewable energy has a positive influence on the behavioural intention to use renewable energy (β=0.33). Therefore, we accept H1. Our results confirm the findings of several previous

studies (Lee, 2009; Prete et al., 2017; Strazzera and Statzu, 2017; Qalati et al., 2022) and contradict those of Liobikienė, Dagiliūtė and Juknys (2021), who found that attitude toward renewable energy has no effect on intention to use renewable energy.

It is important to emphasise that subjective norms have the strongest influence on the behavioural intention to use renewable energy (β=0.65). Therefore, we accept H2. Subjective norms refer to an individual's perception of social pressures or expectations regarding a particular behaviour, e.g., the use of renewable energy. The higher the expectations of those who are important to residential users (friends, neighbours, colleagues) regarding the use of renewable energy, and the people using renewable energy are more accepted in the society, the stronger intention to use renewable energy can be expected. This reflects the influence of important people and the perceived social pressure of the social environment. When an individual's friends, family, or colleagues actively use and support renewable energy, a social norm is created that encourages the individual to "copy" their behaviour. Observing others using renewable energy can foster a sense of social approval and make the behaviour seem more acceptable and desirable. If individuals perceive that they receive encouragement, support, or positive feedback from their social network when using renewable energy, this can strengthen their intention to adopt and use renewable energy sources. Our research findings are consistent with previous research results (Prete et al., 2017; Strazzera and Statzu, 2017; Liobikienė, Dagiliūtė and Juknys, 2021; Xu, Hwang and Lu, 2021; Qalati et al., 2022).

However, in contrast to previous research (Alam et al., 2014; Prete et al., 2017; Qalati et al., 2022), we found that perceived behavioural control does not play a significant role in the development of the behavioural intention to use renewable energy. Since there was no significant relationship between perceived behavioural control and behavioural intention, perceived behavioural control was not included in the nested model, and therefore we rejected H3. It implies that regarding the intention to use renewable energy it does not matter how skilled a residential user is in using modern technologies and renewable energy related mobile apps, how well they understand the data, and graphs, and whether they have the resources, knowledge, and ability to use renewable energy.

Environmental concern reflects an individual's awareness and understanding of environmental challenges, such as climate change, air pollution, and resource depletion. It plays a crucial role in shaping an individual's intention to use renewable energy. Our research results suggest that environmental concern significantly and positively influence attitude toward renewable energy (β=0.44). Therefore, we accept H4. This means that the more we are concerned about climate change and energy problem, the more positive our attitude toward renewable energy. When individuals are concerned about environmental issues, they recognise the need for renewable energy, a sustainable and clean energy alternative. They often have a strong sense of personal responsibility for the environment. They believe that their actions can make a difference in solving environmental problems. In this regard, our research findings are similar to and confirm those of Hartmann and Apaolaza-Ibáñez (2012) and Pothitou, Hanna and Chalvatzis, 2016.

Conclusions

Consistent with the objectives of this research, our research findings extend the knowledge of individual decision making of residential energy end-users by examining their intention to use renewable energy. Extending the Theory of Planned Behaviour to include environmental

concern is shown to be an appropriate theoretical model for investigating the psychological drivers of individual behavioural intention to use renewable energy. As expected, the nested model confirmed that the main factors influencing end-users' behavioural intentions are subjective norms and attitudes toward renewable energy formed by environmental concerns. However, perceived behavioural control did not play a significant role in forming intentions. It suggests that individual's knowledge and skills related to renewable energy, availability of resources and supporting infrastructure do not influence their intention to use renewable energy. Even if individuals feel they know more about renewable energy technologies, how they work, and how to use them effectively, they are unlikely to perceive a higher level of control over their ability to adopt and use renewable energy sources. Perceived behavioural control is also influenced by the availability of resources and the supporting infrastructure for renewable energy use. However, our research findings show that even when individuals perceive that they have access to the necessary resources, such as financial resources, adequate installation space, and reliable information, they do not intend to use renewable energy on a larger scale.

Therefore, we suggest that campaigns to promote the use of renewable energy should emphasise the higher social esteem of current renewable energy users. The message should focus on higher social acceptance. At the same time, this campaign should also aim to raise awareness of the positive effects of renewable energy on the environment and on addressing energy dependence and shortages. Increasing environmental concern among individuals is also crucial to promoting renewable energy use. Strategies to increase environmental concern can include educational programs and campaigns to increase awareness of environmental issues, but also to promote dialogue and engagement through various channels, including community forums, social media, and educational institutions. Making the whole society greener is also important. If residential users perceive that the wider society or their narrower social network disapproves of renewable energy or does not prioritise environmental sustainability, it may hinder their intention to use renewable energy.

The research results have practical implications for EU policy makers and companies interested in promoting the use of renewable energy to achieve all the ambitious goals of the EU's Solar Energy Strategy and the REPowerEU Plan.

This research is also beneficial to academics and researchers interested in the application of TPB in modelling individual decision-making concerning renewable energy use. Our paper proposed and confirmed the extension of the original TPB model to include environmental concerns as a significant indirect determinant of intention to use renewable energy sources.

As we conducted the survey only in Hungary, this is the main limitation of the research. As for future research directions, it would be advisable to repeat this study in several countries of the European Union so that we can compare them to find out country-specific traits of individual decision makers. Another direction of future research is to explore the differences between urban and rural residents in their willingness to use renewable energy sources.

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