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ORIGINAL ARTICLE

Factors affecting household's use of energy-saving appliances in Sri Lanka: an empirical study using a conceptualized technology acceptance model

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Abstract This paper investigates the factors that affect the use/purchase of energy-saving electrical appliances in Sri Lankan households. A theoretical model was developed utilizing the technology acceptance model and incorporating perceived affordability. Twelve hypotheses were tested based on data obtained from a survey conducted in the Sri Lankan Kalutara district for a sample of 384 residences. Statistical analysis was done using IBM SPSS 26 and Smart PLS 3 software. The results show that perceived usefulness and perceived ease of use have significant relationships with attitude and behavioral intention of purchasing energy-saving appliances. The moderating effects of perceived behavioral control to the relationships between perceived ease of use and perceived usefulness are not significant. Also, there was no significant moderating effects of affordability on the relationship between behavioral intention and attitude. The main conclusions were that perceived ease of use, perceived usefulness, attitude, perceived behavioral control, subjective norms, and perceived affordability significantly affected the behavioral intention to purchase energy-saving household appliances. Although Sri Lanka has begun spreading awareness on the use of energy-saving appliances, limited number of studies have reported on this topic. The results of the study suggest that the Ministry of Energy must apply a solid comprehensive awareness program in Sri Lanka, addressing environmental aspects, benefits for the consumers with regards to their health, safety, and interest as well as promoting Energy Star Labels. Additionally, instilling policies involving government loan schemes, low interest rates, and subsidies could serve as motivators for consumers to adopt energy -saving appliances.

Keywords Buying intention · Perceived ease of use · Technology Acceptance Model · Affordability · Subjective norms · Energy-saving appliances

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Introduction

Globally, the demand for energy is increasing significantly; specifically, electrical energy due to its transmissibility and its role in improving quality of

life (Al-Shetwi, 2022). Despite the increase in global awareness and consumer understanding of their role in contributing to the environmental consequences of increased energy use, a large part of the energy consumption is dominated by the household sector (Walia et al., 2022). Worldwide, in 2020 the total energy consumption in the residential sector was estimated to be 6.096.76 billion Kilowatt-hours (bn kWh) in comparison to the total of 27,238.90 bn kWh for all sectors (Perret et al., 2021). Energy-saving behavior can be articulated in a variety of ways; however, the two main approaches to energy-saving behavior are restraint-based energy-saving actions and energy-efficient technology-based actions (Sütterlin et al., 2011). Energy-saving based on energy-efficiency approach or on energy efficiency investments involves the acquisition of new technologies, low-energy appliances or energy-efficient systems that need monetary investments. This behavior substitutes capital for energy and a one-time purchase decision with an initial financial expense but a potential for saving in the future. Energy-saving practices on the other hand are behavioral changes such as scheduling efforts, switching off lights in unoccupied rooms, and unplugging electrical appliances. They are frequent and require efforts from the consumers (Perret et al., 2021). Thus, energy efficiency is largely influenced by preferences and behavioral factors (Cattaneo, 2019).

Some of the factors that influence the monthly electricity consumption of a household include employment, minimum education level of elders, household income, type of house, and the number of members in the family. In Nepal, a study on energy use from 442 households identified intercorrelated energy use between income, occupation, family size, education level, and usage of LED lamps (Shahi et al., 2020). One study even suggested that governments should emphasize more on human capital as this would foster energy conservation (Akram et al., 2019). However, a recent study in Malaysia reported that appliance characteristic factors were the main variables influencing electricity consumption and house characteristics were the least significant. Additionally, the occupant behavior factors had a more significant influence than the socio-demographic factor (Boni et al., 2021). A study on Canadian and United States customer supports this idea and also found that environmental concern and green lifestyle orientation (behavior factors) affected purchasing intention although, unlike the study in Malaysia income still had a very strong effect on intention (Berman Caggiano et al., 2021). On the other hand, household energy-saving behavior has not been extensively researched in developing countries in spite of the high percentages of electricity consumption. In Pakistan, electricity usage is up to 46% and the demand in developing countries is expected to increase by 30% by 2040 (Ali et al., 2019). Therefore, it is crucial to understand household behavior towards energy-saving products.

Worldwide, to understand the factors which affect the purchasing of energy-saving appliances, the following models have been used: Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1975), Theory of Planned Behavior (TPB) (Ajzen, 1991), and the Technology Acceptance Model (TAM) (Davis, 1986). In a Malaysian study, the TPB model was used to test the data from 336 residences and through multiple regression analysis determined that attitude, subjective norm, perceived behavioral control, knowledge, and reasonable price have a positive effect on buying intention (Alam et al., 2019). The TPB model was also used in a study in South Africa and concluded the same as the results established in Malaysia; however, perceived behavioral control was a better predictor of buying intention in contrast to subjective norms as it tends to vary considerably across behaviors and situations (Fatoki, 2020).

The main aim of this study is to provide information that will help manage the increasing electricity demand locally and internationally, by examining household electricity usage which accounts for 38% of total electricity consumption in the country. The study applies theoretical models to examine key factors such as intention, attitude, subjective norms, and perceived behavioral control. The main goal is to understand what are the factors affecting the use/purchase of energy-saving electrical appliances in Sri Lankan households. Recommendations will be made to encourage household consumers to purchase energy-saving appliances to reduce their electricity consumption and ultimately contribute to a decrease in the national-level electricity generation demand. The uniqueness of this study is that it not only looks at the technology acceptance model but it incorporates perceived affordability and examines its moderating effect, which has not been previously done. The majority of the available research looks at only one model or a mix of two existing models. The paper is divided into various sections: The "Current energy situation and literature in Sri Lanka" section looks at the current energy situation and literature in Sri Lanka, the "Theoretical models and

framework" section looks at the theoretical models and framework, the "Materials and Methods" section covers the materials and methods used, the "Results" and "Discussion" sections are the results and discussions, the "Policy recommendations" section includes policy recommendations, the "Research contribution and theoretical implication" section looks at the research contribution and theoretical implication, and the "Conclusions" section is the conclusion.

Current energy situation and literature in Sri Lanka

In Sri Lanka, there is a high demand for electricity and with the income levels of the population inclining electrification has exceeded 98%. Moreover, according to the forecast of Asian Development Bank (ADB) and United Nations Development Programme (UNDP) in Sri Lanka, the electrical energy demand in 2034 will be 34 TWh which is a 153% increase from 2016. This is a significant increase; especially since Sri Lanka aims to generate 100% of electricity from renewable sources by 2050 (Singh et al., 2017). It has been reported that by the end of 2023, the aim is to produce 2000 megawatts; however, a recent national audit conducted in February 2022 found that the state-owned utility provider Ceylon Electricity Board (CEB) has not yet implemented the planned renewable power plants (mainly solar and wind) projects (Thomson Reuters Foundation, 2022). Consequently, electricity usage is increasing but electricity generation facilities are not being developed at the same rate; thus, energy conservation is essential. In 2021, the main energy sources for Sri Lanka were oil (62.97%), coal (15.8%), and hydropower (17.50%). Wind, solar, and other renewables only accounted for approximately 4% (Ritchie et al., 2022).

Due to the limitation in available literature discussing the current electricity situation in Sri Lanka, comparisons are very difficult. Additionally, conclusions made are based on specific districts and the customer-perceived values may be different between provinces and districts. Perceptions of users may vary in the remote areas from different geographies and economic features. A study in 2020 showed that a key trend is that environmental concerns do not have a significant impact on the purchasing impact (Morapitiya et al., 2020). This could be attributed to the lack of awareness. This is supported by a survey conducted in 2018 which represented five main districts of Sri Lanka and samples 423 individuals. It concluded that despite consumers having a favorable opinion towards environmental protection 40% are unfamiliar with terms such as green/sustainable consumption and 52% do not agree that buying these products would fulfil the individual responsibility to protect the environment. Also, the survey found that the main determinant of the purchase decision was the price of the product followed by the quality (National Cleaner Production Centre, 2018). The only study that was found in Sri Lanka which was relevant to this paper was an article on the energy efficiency of a building depending on the occupants. This study examined factors such as area, number of people, and presence of air conditioning. It did not look at the effects of factors such as social norms, perceived usefulness, and affordability on the purchasing of energy-saving appliances (Pathirana & Halwatura, 2020).

Theoretical models and framework

Theoretical models

A literature review on models which examined behavioral intention was conducted and used to develop a conceptual framework for the model to be used in the research. The three models assessed included the theory of reasoned action (TRA) (Ajzen & Fishbein, 1975), theory of planned behavior (TPB) (Ajzen, 1991), and technology acceptance model (TAM) (Davis, 1986).

The TRA model suggests that an individual's behavior is determined by their behavioral intention which in turn is influenced by their attitude and subjective norms. Attitude being the user's assessment toward the technology, whereas the behavioral intention represents the degree to which the user is willing to carry out a certain behavior (Di Pietro & Pantano, 2012). TPB is an extension of TRA and states that an individual's behavior is explained by his/her behavioral intention. This is the individual's perceptions of the presence/absence of resources or opportunities for performing a behavior which is affected by not only attitude and subjective norms but also perceived behavioral controls. Thus, it is considered

to be an accurate measure of consumer pro-environmental behavior (Hossain et al., 2022). Lastly, TAM takes this one step further and states that the user's intention to use a system is determined by the user's belief about that system, hence, adding two additional elements: perceived usefulness and perceived ease of use (description of factors can be found in Table 1). This is the most broadly utilized model to predict customer behavior in accepting new technology (Yang & Danwana, 2021; Zhang & Liu, 2022). When comparing it to TPB, TAM gives a slight experimentally preferred position, is a lot less complex, simpler to utilize and a better model to show an individual's attitude toward a type of technology or innovation as it shows their subsequent desire to adopt that technology based on their views about the perceived usefulness and the perceived ease of use of that technology or appliance (Nguyen Thi et al., 2022). The TAM, in particular, uses the intention to adopt technology as a dependent variable to determine the degree to which a technology is used (Hossain et al., 2022).

Conceptual framework

The hypothetical structure chosen for this research paper was based on the technology acceptance model. In addition, perceived affordability was incorporated into the theoretical model to check the moderating effect of the relationship between attitude towards the use/purchase of energy-saving appliances and behavioral intention to use/purchase energy-saving appliances. The conceptual model used is illustrated in Fig. 1.

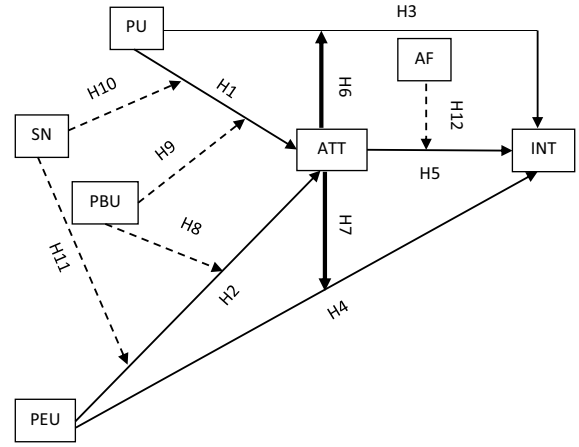

Fig. 1 Conceptual theory with factors and hypotheses

The main factors labelled in Fig. 1 are discussed below.

1. PU: perceived usefulness of energy saving appliances. This is the degree to which the consumer assesses whether the technology is useful and beneficial in comparison with the previous technology. An appliance is high in perceived usefulness when the user believes that a positive use-performance relationship exists (Davis, 1989).
2. SN: subjective norms on energy-saving appliances use. Subjective norms are characterized as any social influence which may decide whether the person conducts the behavior. In other words, the perceived social pressure to perform or not

Table 1 Summary of factors and identifiers (part 1)

Factor	Indicator		Question reference in survey
	Identifier	Measure	
Perceived usefulness of energy-saving appliances	PU1	Energy-efficient appliances on energy saving	Q *14*
	PU2	Comparison of energy-efficient appliances and common appliances	Q 15
	PU3	Possibility to reduce electricity bill	Q 16
	PU4	Improvement to quality of life	Q 17
	PU5	Whether energy-efficient appliances are useful	Q 18
Perceived ease of use of energy-saving appliances	PEU1	Perception of energy efficient appliances versus common appliances	Q 19
	PEU2	Operational convenience of energy-efficient appliances	Q 20
	PEU3	Complexity of function of energy-efficient appliances	Q 21
	PEU4	Ease of use of energy-efficient appliances	Q 22

perform a behavior, in this case, purchasing an energy-saving appliance (Ajzen, 1991).

3. PEU: perceived ease of use of energy saving. The degree to which the user judge's technology as being easy (free of effort) or difficult to use. If all other features of an appliance are similar it is claimed that an appliance perceived to be easier to use will be more likely to be accepted by users (Davis, 1989).
4. PBU: perceived behavioral control on purchase/use of energy saving. This is characterized as an individual's level of confidence in their ability to perform the behavior based on how easy or difficult they perceive their performance in terms of obstacles or facilitators. It is assumed to reflect past experiences or anticipated impediments (Ajzen, 1991).
5. ATT: attitude on energy-saving appliances. This is characterized as the degree to which an individual perceives an action based on evaluation, as favorable or unfavorable (Ajzen, 1991).
6. AF: perceived affordability to purchase energy-saving appliances. This refers to the cost of new and upgraded equipment according to a society's wage level (Bhattacharjee & Reichard, 2011)
7. INT: intention to purchase energy-efficient appliances. This indicates how hard people are willing to try and how much effort they are planning to put in to execute their actions. Usually, the stronger the intention to engage in a behavior the more likely it will be performed; however, to a degree, this performance will be dependent on other factors such as time, money, and skills (Ajzen, 1991).

Additionally, the 12 hypotheses (H1–H12) shown in Fig. 1 and are further elaborated below:

- H1: positive relationship between PU and ATT.
- H2: positive relationship between PEU and ATT.
- H3: positive relationship between PU and INT.
- H4: positive relationship between PEU and INT.
- H5: positive relationship between ATT and INT.
- H6: mediating effect of ATT on relationship between PU and INT.
- H7: mediating effect of ATT on relationship between PEU and INT.
- H8: moderating effect of PBU on relationship between PEU and ATT.
- H9: moderating effect of PBU on relationship between PU and ATT.
- H10: moderating effect of SN on relationship between PU and ATT.
- H11: moderating effect of SN on relationship between PEU and ATT.
- H12: moderating effect of AF on relationship between ATT and INT.

These hypotheses were tested and either accepted or rejected based on the results obtained. A set of valid indicators for each factor were identified based on the literature review and tabulated in Tables 1, 2, and 3. The tables also include a reference to the survey questions (Online Resource 1) which were used to measure each indicator.

Materials and methods

The study presented in this study consisted of a comprehensive literature search to understand the factors that can affect or influence Sri Lankan choices for energy-saving appliances. The study focuses on household perception of usefulness and ease of use of energy-saving appliances that leads to attitude towards energy-saving household appliances, leading to intention followed by energy-saving behavior. Once a framework was built, a series of surveys and questionnaires were distributed as shown in the sections below.

Survey/questionnaire

A survey was conducted in the Kalutara district to collect the data. Kalutara district was selected as the representative district because Sri Lanka has over 5.5 million houses and so it is difficult to collect data representing the entire country. A pilot study was conducted; however, the pilot survey readings were also used for the master survey due to the low responses received from participants. All participants were asked for their consent prior to collecting the responses. This survey was composed of 44 questions; the first 13 were on demographic variables such as age and gender the remaining 31 questions were to do with the factors and indicator, a 5-point Likert scale was also used. Additionally, Tables 1, 2, and 3 also show which question correlates with each indicator. In addition to

Table 2 Summary of factors and identifiers (part 2)

Factor	Indicator		Question reference in survey
	Identifier	Measure	
Subjective norms on energy-saving appliance use	SN1	Pleasantness of having energy-efficient appliances	Q 23
	SN2	Respectable or important people's influence on the use of energy-efficient appliances	Q 24
	SN3	Family and friends influence on the use of energy-efficient appliances	Q 25
	SN4	Influence of people around on the use of energy-efficient appliances	Q 26
	SN5	Social trend of using energy-efficient appliances	Q 27
Intention to purchase energy-efficient appliances	INT1	Intention to buy energy-efficient appliances in future	Q 28
	INT2	Willingness to pay higher prices for energy-efficient appliances in future	Q 29
	INT3	Plans to buy appliances with better energy efficiency in the future	Q 30
Perceived behavioral control on purchase/use of energy-saving appliances	PBC1	Grasp of new functions of energy-efficient appliances	Q 31
	PBC2	Income to own energy-efficient appliances	Q 32
	PBC3	Ability to deal with problems in the use of energy-efficient appliances and solve them	Q 33

Table 3 Summary of factors and identifiers (part 3)

Factor	Indicator		Question reference in survey
	Identifier	Measure	
Attitude on energy-saving appliances	ATT1	Intention towards using energy-efficient appliances	Q 34
	ATT2	Willingness to use energy-efficient appliances	Q 35
	ATT3	Attitude toward using energy-efficient appliances	Q 36
	ATT4	Positive effect on life of using energy-efficient appliances	Q 37 and 38
Perceived affordability to purchase energy-saving appliance	AF1	Limitations of investment	Q 39
	AF2	Priority of investment	Q 40
	AF3	Effect of government incentives for purchase	Q 41
	AF4	Effect of low-interest government loans for purchase of appliances	Q 42
	AF5	Effect of low-interest government loans for replacement of inefficient appliances	Q 43
	AF6	Adequacy of salary for purchase of energy-efficient appliances	Q 44

the close-ended questions, a space was provided for respondents to add any other important aspects they believed were important to the study. The full survey can be found in Online Resource 1.

Content and face validity

The content validity is the extent to which the set of items comprehensively covers the different components in a survey (Rubio, 2005). Consumer purchases and use of household energy-saving appliances were used for this purpose. Literature and conceptual frameworks are usually used to achieve content validity and so the conceptual model developed in Fig. 1 was used as a basis to create the survey. Moreover, face validity investigates whether the items are appropriate and relevant to consumers who use the measure on a day-to-day

basis in this case: household's energy-saving appliances. Face validity, unlike content validity, does not rely on established theory for support. Hence, this is subjective and a question which may seem irrelevant, judgemental, distressing, ambiguous, or difficult to answer for one consumer may differ to another (Fink, 2010). Based on the target audience selected care was taken to choose questions which were simple yet covered the factors and indicators which needed to be assessed.

Target population and target sampling

The total population of households in Kalutara district exceeds 75,000 but is less than 1,000,000; thus, the minimum sample size that should be used is 384. However, the final data which was collected for this paper was based on a sample size of 414. Approximately 300 of the participants were male of ages ranging from 15 to 55 years (majority were ages 25–40) with incomes ranging from 30,000 to 120,000 rupees. The sampling method used was a mix of random sampling (47.34%) and convenience sampling (52.66%) according to the response rate. This non-probability sampling method was chosen due to a limitation in time and costs. Moreover, the necessary consent was taken and the email addresses were retrieved from Sri Lanka Telecom's (SLT) customer database. The questionnaire was then emailed to 2976 recipients in Kalutara District. In addition to emailing these questionnaires, printed hard copies were also distributed among factory employees of Royal porcelain Ltd, Merbok MDF Lanka Ltd, and residents in Panadura, Kalutara, and Aluthgama. The languages of the questionnaire were Sinhala and English. The questionnaire in English was emailed to about 100 selected addresses, after confirming that this was the desired language. The remaining questionnaires were emailed in Sinhala. The data acquired was then analyzed using IBM SPSS 26 and Smart PLS 3 software. These generate various statistical outputs to predict the relationships among variables and to test the 12 hypotheses.

Results

Data cleaning and normality test

The data collected from the survey was entered into the SPSS software and underwent a series of tests as summarized in Fig. 2. The hypotheses were then tested using SMART PLS 3.

Data cleaning was performed using box plots to identify outliers. Whenever more than 4 outliers were identified, the measurement was rejected. This resulted in the removal of 37 cases; hence, 377 cases remained. Normality of the variables was done by using the Kolmogrov-Smirnov (KS) and Shapiro–Wilk (SW) tests. For the data to be significantly normal, the KS and SW values should be larger than 0.5. The result was 0 significance for all the variables showing low normality for the data.

Reliability analysis

Reliability tests are conducted to test the measurement scale's internal consistency; this is done by using Cronbach's alpha coefficient (Sekaran, 2006). If the coefficient is higher than 0.6, then the constituents are good enough to measure the concept. In this study, the factors defined previously (PU, PEU, SN, INT, PBC, ATT, and AF) were separately tested for scale reduction using SPSS and certain constituents were removed to improve Cronbach's alpha. The total number of constituents was reduced from 31 to 24 and all Cronbach's alpha exceeded 0.6 as shown in Table 4.

Validity analysis

Validity tests ensured adherence to the correct design of the instrument and measurement of the basic concept (Sekaran, 2006). The two main tests were Kaiser–Meyer–Olkin (KMO) and Bartlett's test. The KMO showed a sampling adequacy of 0.863. KMO values between 0.8 and 1 indicate the sampling is adequate; hence, our result shows the adequacy of the study. Moreover, Bartlett's test obtained a significance of 0.01.

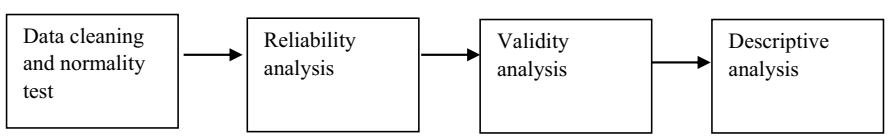

Fig. 2 Diagram of the tests and analysis conducted using SPSS Software

Table 4 Reliability analysis for factors using Cronbach's Alpha

Factors	Number of constituents in factors	Cronbach's Alpha	Number of constituents in factors after reliability test	New Cronbach's Alpha
PU	5	0.759	5	0.759
PEU	4	0.741	4	0.741
SN	5	0.766	2 (SN5, SN1, SN2 removed)	0.893
INT	3	0.526	2 (INT2 removed)	0.712
PBU	3	0.611	3	0.611
ATT	5	0.855	5	0.855
AF	6	0.685	3 (AF1, AF6, AF2 removed)	0.786

Table 5 Criticality Scale

Criticality	Value
Low	1.000–2.999
Moderate	3.000–3.999
High	4.000–5.000

This is less than 0.05 and concludes that the correlation between variables is strong.

Descriptive analysis

The descriptive analysis was based on the mean value of responses for each factor (PU, PEU, SN, INT, PBC, ATT, and AF) to the use and/or purchase of household energy-saving appliances. Table 5 shows the measurement criterion for the mean value and Table 6 shows that most results varied from high to moderate with two factors demonstrating a slightly low criticality.

An ANOVA test analysis between conceptual model variables and other demographic variables was conducted to identify any existing relationships. The same test was then done between some of the demographic variables to see if there were any relationships within. In other words, one-way ANOVA test can be used to check the significance of each categorical variable to each conceptual model variable. The results are shown in Tables 7 and 8. If the *p*-value is less than or equal to 0.05 (values in bold), then there is a significant relationship. The last column labelled J vs A-M illustrates the results of a separate ANOVA test done on monthly electricity consumption Vs factors A-M.

The relationships between the factors obtained in this study are the following:

1. Gender—ATT
2. Age—PU, SN, monthly electricity consumption, and monthly electricity bill
3. Number of family members—PEU, monthly electricity consumption, monthly electricity bill, and square area of house
4. House type—AF, income, monthly electricity bill, and square area of house
5. Income—PU
6. Presence of school children—monthly electricity consumption and monthly electricity bill
7. Minimum education level—INT and PBC
8. Religion—minimum education level
9. Race—no relationships
10. Monthly electricity consumption (first ANOVA test)—no relationships
11. Monthly electricity consumption (Second ANOVA test)—age, number of family members, house type, income, presence of school children, min education level of elders, monthly electricity bill, employment, and square area of house
12. Monthly electricity bill—PU, INT, PBC, ATT, and AF
13. Employment—income and minimum education level of elders
14. Square area of house—PU, SN, INT, PBC, ATT, and AF

In general, the results of ANOVA show that gender has a significant effect on attitude, subjective norms significantly differ according to the age of the respondent, and perceived ease of use of energy-saving appliances is significantly different depending on the number

Table 6 Descriptive analysis for factors

Factor	No of constituents in factor	Mean	St. deviation	Mean -/ + St deviation	Criticality	Analysis
PU	5	3.994	0.483	3.511–4.477	Moderate–high	Households strongly perceive that efficient appliances can save energy, have higher working efficiency than common appliances, can reduce their energy bills and improve their quality of life
PEU	4	3.686	0.559	3.127–4.245	Moderate–high	Households view efficient appliances as being better than ordinary appliances, easier to operate, and are not technically complicated
SN	2	3.937	0.586	3.351–4.523	Moderate–high	Households like to have efficient appliance because they are satisfying to have, respectable/important people own them and because family, friends, and people around them use them
INT	2	3.936	0.586	3.350–4.522	Moderate–high	Households are willing to pay higher prices and buy appliances with higher energy efficiency
PBU	3	3.424	0.660	2.764–4.084	Low–high	Households have a moderate (2.764 is close to 2.99) to high grasp of functions of energy-saving appliances, have income to purchase these appliances and could deal moderately with problems occurring during their use
ATT	5	4.034	0.453	3.581–4.487	Moderate–high	Households look forward to purchasing/using energy-saving appliances and would recommend them to others
AF	3	3.712	0.736	2.976–4.448	Low–high	Households need government incentives, loans with low interest rates to purchase energy-saving appliances as their salaries are moderately (2.976 is close to being moderate criticality) sufficient to buy such items

Table 7 ANOVA test analysis between conceptual model variables and other demographic variables

	PU	PEU	SN	INT	PBC	ATT	AF
A. Gender	0.08	0.92	0.45	0.11	0.68	**0.02**	0.85
B. Age	**0.05**	0.39	**0.01**	0.08	0.67	0.18	0.57
C. Number of family members	0.37	**0.05**	0.13	0.77	0.60	0.95	0.38
D. House type	0.37	0.31	0.13	0.42	0.34	0.35	**0.03**
E. Income	**0**	0.93	0.03	0	0	0	0.01
F. Presence of school children	0.15	0.31	0.53	0.70	0.11	0.29	0.19
G. Minimum education level of elders	0.09	0.24	0.86	**0**	**0.01**	0.16	0.14
H. Religion	0.73	0.69	0.24	0.09	0.91	0.11	0.30
I. Race	0.57	0.65	0.20	0.77	0.55	0.71	0.89
J. Monthly elec. consumption	0.64	0.17	0.15	0.28	0.60	0.55	0.52
K. Monthly elec. bill	**0.05**	0.52	0.06	**0.02**	**0**	**0.01**	**0**
L. Employment	0.36	0.67	0.24	0.94	0.63	0.86	0.39
M. Square area of house	**0.01**	0.79	**0.01**	**0**	**0**	**0**	**0**

The values in bold are those that are equal to or less than 0.05

Table 8 ANOVA test analysis between demographic variables

	E	G	J	K	M	J vs A-M
A. Gender	0.147	0.316	0.922	0.712	0.626	0.57
B. Age	0.058	0.045	**0**	**0.036**	0.008	**0**
C. Number of family members	0.662	0.096	**0.001**	**0**	**0.012**	**0**
D. House type	**0**	0.667	0.257	**0.003**	**0.002**	**0.05**
E. Income	-	-	-	-	-	**0**
F. Presence of school children	0.989	0.982	**0.024**	**0.005**	0.848	**0**
G. Minimum education level of elders	-	-	-	-	-	**0**
H. Religion	0.233	**0.006**	0.804	0.086	**0**	0.37
I. Race	0.66	0.487	0.578	0.871	0.595	0.87
J. Monthly elec. consumption	-		-	-	-	-
K. Monthly elec. bill	-	-	-	-	-	**0**
L. Employment	**0.005**	**0**	0.072	0.248	0.294	**0.01**
M. Square area of house	-	-	-	-	-	**0**

The values in bold are those that are equal to or less than 0.05

of members of the household. Household income has a significant effect on perceived usefulness, subjective norms, perceived behavioral control, attitude, and perceived affordability and behavioral intention of use/purchase of energy-saving appliances. In addition to all the relationships above, it was noted that though there is a significant effect of monthly electricity bills on perceived behavioral control, attitude, perceived affordability, and intention to use/purchase energy-saving household appliances, there was no sign of significance of monthly electricity consumption to these variables as most of the respondents had a good sense of what the monthly electricity bill was but not a clear idea of how much was their monthly electricity consumption.

Partial least squares structural equation modelling (PLS-SEM)

Partial least squares equation modelling was done using SMART PLS3 to assess the relationships and hypothesis further. However, to ensure that the model was adequate, additional analysis was conducted. Firstly, Cohen's indicator was utilized to assess the fitness of the model. *F* square values larger than zero indicate that the model is fit for measuring the intended construct (Cohen, 1992). Table 9 shows that most relationships satisfy this condition.

Stone-Geisser's values (*Q* square) were then used to measure predictive variance for the two predictor variables of the model: attitude and intention. Both variables had a *Q* square value larger than zero. This indicates that the model is suitable for the prediction of that variable. After the suitability of the model was confirmed, the hypotheses were tested. Hypothesis with *p* values less than 0.05 were accepted. In this case, the accepted hypotheses were H1–H5 and H8–H12 were rejected. For hypotheses 6 and 7, unlike the other hypotheses, the direct and indirect effects were examined to determine whether they were accepted or rejected. If the indirect effect was higher than the direct effect, then the hypothesis was accepted. The results of this study showed that for hypothesis 6 (H6) the indirect effect yielded a value of 108.072 vs. 2.631 for the direct effect. Similarly, hypothesis 7

Table 9 *F* square values for different relationships between intention, attitude, and other variables

Relationship	F square value
Affordability- > intention	0
Attitude- > intention	0.289
Mod effect of AF to PU and INT- > intention	0
Mod effect of PBC to PEU and ATT- > attitude	0.015
Mod effect of PBC on PEU and ATT- > attitude	0
Mod effect of PBC on PU and ATT- > attitude	0.011
Mod effect of SN to PU and ATT- > attitude	0.001
Perceived behavioral control- > attitude	0.051
Perceived ease of use- > attitude	0.017
Perceived ease of use- > intention	0.005
Perceived usefulness- > attitude	0.174
Perceived usefulness- > intention	0.025
Subjective norms- > attitude	0.025

Table 10 Additional relationships investigated

Relationship test	*P*-value	Result
Effect of perceived affordability on attitude	0	Perceived affordability strongly affects attitude
Effect of perceived affordability on behavioral intention	0	Perceived affordability strongly affects behavioral intention
Effect of subjective norms on behavioral intention	0	Subjective norms strongly affect behavioral intention
Effect of perceived behavioral control on behavioral intention	0	Perceived behavioral control strongly affects behavioral intention
Effect of perceived behavioral control on attitude	0	Perceived behavioral control strongly affects attitude

Table 11 Mediating effects of hypothesis

Hypothesis	*T*-value for indirect effect	*T*-value for direct effect	Results
H6	108.072	2.631	The indirect effect is larger than the direct effect. Hence a strong mediation effect exists between perceived usefulness and behavioral intention
H7	99.827	2.695	An indirect effect is higher than the direct effect. Hence a strong mediation effect exists between perceived ease of use and behavioral intention

Table 12 Moderating effects of hypothesis

Hypothesis	Independent variable	Dependent variable	Moderating variable	*P*-value	Results
H8	PEU	ATT	PBU	0.202	Rejected
H9	PU	ATT	PBU	0.555	Rejected
H10	PU	ATT	SN	0.514	Rejected
H11	PEU	ATT	SN	0.324	Rejected
H12	ATT	INT	AF	0.973	Rejected

(H7), yielded values of 99. 827 vs. 2. 695 for indirect and direct effects, respectively, hence making our hypothesis acceptable. Additional relationships were then tested using SMART PLS 3. The results are shown in Table 10.

Moderating and mediating effects

The moderating and mediating effects of the different hypotheses were tested using Smart PLS-SEM and the results can be seen in Tables 11 and 12 below.

Based on the tables, Hypotheses H6 and H7 on mediating effects were accepted. Hypotheses H8 to H12 on moderating effects of affordability, subjective norms and perceived behavioral control were rejected.

Discussion

The results of this study show that perceived usefulness and perceived ease of use have significant relationships with attitude and behavioral intention of purchasing energy-saving appliances. The moderating effects of perceived behavioral control to the relationships between perceived ease of use and perceived usefulness are not significant. Also, there was no significant moderating effects of affordability on the relationship between behavioral intention and attitude. Cross-tabulation of data of primary demographic variables under the ANOVA test can be summarized by the significant relationship between monthly electricity consumption and square area of house, employment, minimum education level of elders (above 18 years), presence of children attending school, household income, type of house and the number of members in the family. A study in Cambodia had similar findings and concluded that the electricity consumption of residents had significantly been influenced by income, level of education and number of people per household (Noeurn, 2021). Moreover, positive relationships between perceived usefulness and attitude (H1), and perceived ease of use and attitude (H2) were obtained in this study

using SMART PLS3 analysis. This result is supported by a similar study carried out in China which concluded that perceived ease of use influenced perceived usefulness and that these two factors influenced consumers' attitude towards purchasing (Hua & Wang, 2019). However, the study in China also determined that the relationship between perceived usefulness and behavioral intention (H3) was found to be insignificant unlike the present study which proves it to be significant. It has been reported that the reason for this insignificance is that the perceived usefulness of energy efficient appliances is not too attractive and so there is not a strong desire to buy them (Hua & Wang, 2019). This is perhaps because their study mainly targeted young household customers and not various age segments. Most of this sector are focused on trends as opposed to usefulness.

In Pakistan households' attitude and perceived behavioral control are found to be significant determinants of intention to purchase energy-saving household products, which agrees with the results obtained in this study (Ali et al., 2019; Waris & Hameed, 2020a, 2020b). Correspondingly, based on the hypotheses H1-H5 and the literature review performed, the majority of studies including ours showed the mediating effect of attitude on: perceived usefulness and behavioral intention (H6) and perceived ease of use and behavioral intention (H7) (Muhammad et al., 2020; Zhang & Liu, 2022). Although, a study in Malaysia households showed that attitude has no significant influence but rather social interaction and quality were found to be critical determinants of intention. This is supported by a study in Bangladesh which showed that consumers are easily influenced by friends, family, and people's opinions when purchasing energy-efficient household products and that the more positive the comments were about the appliances the higher the purchases (Hossain et al., 2022). On the other hand, Ali et al. (2019) showed that subjective norms do not play a major role in determining consumer consumption behavior towards energy saving home appliances in Pakistan. This contrasting finding could be a result of cultural differences between multiple countries. Another factor could be that the researcher did not take into consideration the effect of energy labeling as studies indicated that those who knew the contents of the label had a deeper understanding of the advantages of energy saving appliances and so were less inclined to follow what others were doing (subjective norms) (Li & Cao, 2021).

When comparing the results obtained in this study to other studies around the world, it was observed that similar factors were observed in studies conducted in Jordan (Akroush et al., 2019), Pakistan (Alam et al., 2019) and China (Hua & Wang, 2019); which concluded that subjective norms have no effect on buying intention. Additionally, (Fatoki, 2020) and (Hua & Wang, 2019) stated that perceived benefits also affected buying intention. As shown in Table 13, most studies worldwide obtained similar findings; however, there are slight variations which perhaps are due to various factors such as: cultural differences, the age groups which were investigated and media influences. Table 13, summarizes various studies conducted in different countries which investigated the use of energy saving appliances or renewable energy in homes, mainly developing countries with close conditions to those in Sri Lanka, yet no studies apart from the present study have been obtained in Sri Lanka.

Some limitations were found in this study, in order to accomplish the goals of this study several areas of improvement are suggested including:

1. Two additional factors: the actual awareness (how environmentally aware are the respondents) and the dependence of purchase of energy-saving appliances on energy labeling must be added to the current model. Currently most research looks at increasing the affordability of energy saving appliances through government loan schemes, low interest rates and subsidies. This does motivate consumers especially in places where electricity costs are high as is the case in Sri Lanka but there may be possible alternatives to this method.
2. Due to time limitation this research paper mainly measured behavioral intention of purchasing energy saving appliances, not the actual purchasing behavior. Researchers can account for this by carrying out research with a time gap of several years in between to obtain more accurate data on actual behavior of purchasing energy-saving household appliances.
3. Sampling more than one city/district. This study was limited to Kalutara District for future studies researchers should cover different regions as geographical cultural and climatic aspects effect data.

Table 13 Studies investigating the use of energy saving appliances or renewable energy in homes within the region

Country	Area of study	Model used	Main findings
Bangladesh (Hossain et al., 2022)	Consumers attitudes and trust in energy efficient household appliances	TRA and TPB	Environmental knowledge, eco-label knowledge, attitude, and green trust all positively correlate with consumer pro environmental behavior
Malaysia (Harun et al., 2022)	The determinants of purchasing intention of energy efficient appliances	TPB with integration of social interaction and quality of energy efficient appliances	Perceived behavioral control and subjective norms exert a significant and positive effect on consumers' intention Attitude has no significant influence Social interaction and quality were found to be critical determinants of intention
Ghana (Yang & Danwana 2021)	Investigate the acceptance of renewable energy	TAM	Environmental awareness and affordability are the biggest predictor of the intention to use renewable energy in Ghana
China (Zhang & Liu, 2022)	Investigate the willingness to adopt eco-friendly smart home services (ESHS)	TAM	Perceived ease of use, perceived usefulness, knowledge, and environmental consciousness significantly and positively influence consumers' intention
Pakistan (Muhammad et al., 2020)	Investigate the impact of consumers' intention factors on willingness to pay (WTP) for renewable energy (RE)	TPB and added two factors: belief about RE cost and environmental concern	Attitude, subjective norms, and perceived behavioral control positively moderate the relationship RE cost has a negative effect Environmental concern has no effect
Pakistan (Muhammad et al., 2021)	Factors affecting consumers' intention to adopt RE for household use in Pakistan	TPB and 3 elements: perception of self-effectiveness, perception of neighbor's participation, and belief about RE benefits)	Perception of self-effectiveness, awareness of RE, and perception of neighbor's participation have a positive effect on consumers' intention Cost of RE generation has a negative effect Environmental concern had a neutral effect
Pakistan (Waris & Hameed, 2020a, 2020b)	Evaluate consumers' purchase intention of energy-efficient appliances	Covariance-based structural equation modeling (CB-SEM)	Knowledge of eco-labels, environmental concern, attitude, and perceived consumer effectiveness affected intention
Pakistan (Hameed & Khan, 2020)	Prediction of consumer's sustainable behavior for home appliances	The goal-framing theory (GFT) on the energy-saving air conditioners called inverter air conditioners (IACs)	The importance of the motivational factors: gain motivations, hedonic motivations, and normative motivations and the negative moderation of perceived behavior control (PBC) in affecting consumers' sustainable behavior

4. The software used for analyzing the research data was limited to SPSS and SMART PLS. In future other software should be used.

Policy recommendations

Previously, the International Energy Agency (IEA) classified energy efficiency policies in seven categories including; research, development, and deployment (RD&D); economic instruments; information and education; policy support; regulatory instruments; behavioral measures and voluntary approaches (Bertoldi, 2020). The authors of this work recommend that governments should invest in energy awareness. Energy awareness is crucial as it has a positive and significant effect on consumers purchasing intention energy (Akroush et al., 2019). According to a recent study in Pakistan the reason for this is that the most influencing factors in purchase of energy saving appliances are environmental concerns and the products functional value (Waris & Hameed, 2020a, 2020b). However, a recent study in Sri Lanka showed that the use of energy saving technology (in this case efficient LED technologies) is not yet prioritized, especially in the industrial sector. The main reasons for this are the higher initial costs, lack of knowledge and low governmental intervention.Therefore, a comprehensive awareness program should be established in Sri Lanka and be accessible to all the population. Although, as a study in the UK suggested, being environmentally aware and actively concerned about energy efficiency, does not necessarily lead to a desire or intention to install energy-efficient technologies (Pelenur, 2018). Hua and Wang (2019) show that consumers' willingness to buy energy-efficient appliances was not based on their environmental awareness but rather how this purchase would affect their health, safety, and interest. Moving forward these factors should be clearly highlighted when a consumer is looking at purchasing an energy efficient appliance.

Another important recommendation is for manufacturers to focus on marketing the product itself as opposed to its environmental benefit. Providing all information ensures that the population is more informed on the actual characteristics of the products they buy. Considering the above, the Sustainable energy authority (SEA), a government institution established for energy management in Sri Lanka, has been implementing public awareness programs on energy-saving appliances, newly evolved regulations and law enforcement for appliance manufacturers and importers. They have prepared and obtained legal clearance for compulsory energy labeling for refrigerators, ceiling fans, and tubular fluorescent lamps. Also, they have launched voluntary energy labeling for computers, prepared minimum energy performance standards for LED panel lamps, arranged test facilities to assess the energy efficiency of appliances and published compulsory regulations for labeling LED lamps through gazettes (Securities and Exchange Commission of Sri Lanka, 2020).These energy labels/eco labels have shown high success rates in many countries as they guide consumers. However energy labels on their own are not sufficient. Policies on minimum energy performance standards for specific products are crucial. Also reinforcing the label with an energy tax, as done in Germany and other countries through residential electricity charges, may motivate users more. (IEA, 2021) Additionally, the government can use the energy performance ladder developed by IEA, for developing and implementing these different policies under a single consistent set of performance thresholds.

There are only a few ventures who manufacture energy saving appliances such as LED lighting solutions and so there is a limited supply (Jayaratne et al., 2021)Hence, it is evident there is a gap in the energy and power technology sector in Sri Lanka; therefore, there is a need for new experts in this field and green marketers need to continue to encourage existing consumers to buy energy-efficient products by enhancing the uniqueness and social value of these items. Marketers should also seek the support of experts in the field, to aid in creating awareness of their importance. In general, policies could follow the example adopted by the European Union aiming at reducing barriers in consumers acceptance. Campaigns, training and media use targeting consumer information as well as the inclusion of carbon pricings and carbon taxes which induce behavioral changes (Bertoldi, 2020).

Research contribution and theoretical implication

This research contributes to the study of human behavior when it comes to sustainable consumption.

Looking at the theoretical perspective, the study encompasses a variety of aspects needed to conduct empirical research such as consumer motivations and behavioral intentions. The current research has contributed by expanding the theoretical framework of the technology acceptance model by incorporating perceived affordability. Furthermore, it is a good contribution to the advancement of the body of knowledge in this area for future academic researchers to broaden it further. Additionally, this paper provides some needed knowledge on consumer attitudes, norms and intentions leading to consumers choices of energy-saving appliances which can be used by policy and decision-makers, regulators, and marketing professionals.

Conclusions

To conclude, behavioral intent-based factors affecting household energy-saving appliances' buying intentions and demographic factors affecting household electricity consumption were evaluated in this study. A framework for the research based on TAM was created and conceptualized. Perceived ease of use and perceived usefulness were taken as independent variables, behavioral intention as a dependent variable and attitude as a mediating variable. Moreover, affordability, subjective norms and perceived behavioral control were taken as moderating variables. Perceived ease of use, perceived usefulness, attitude, perceived behavioral control, subjective norms and perceived affordability significantly affected the behavioral intention to purchase energy-saving household appliances. Creating the perception of the usefulness and ease of use of energy-saving appliances in the minds of the Sri Lankan households will encouraged them to purchase energy-saving appliances. Additionally, social impacts, represented by subjective norms, majorly affected the household's attitude towards energy-saving appliances. Therefore, based on the current energy situation in Sri Lanka the use of energy saving appliances is highly desirable. The population seems to have some knowledge regarding the issue; however, there is a need for improvements in awareness by governments including awareness campaigns, programs and incentives. The results show that it is evident that there is a future for this market to grow further and to witness a much higher demand. Although, for this to happen governments, manufacturers and suppliers must intervene and ensure that the population is informed and understand the benefits of using energy saving appliances. Hence, this paper has provided a theoretical model which is applicable to similar studies worldwide.

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Author contribution WK: conceptualization, methodology, and formal analysis; WJ: methodology and formal analysis; FS: writing—original draft, writing—review and editing, and validation; SI: writing—original draft and writing—review and editing; SD: supervision, resources, and project administration. All authors have read and agreed to the published version of the manuscript.

Declarations

Conflict of interest The authors declare no competing interests.

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