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Does psychological empowerment improve renewable energy technology acceptance and recommendation? Evidence from 17 rural communities

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ABSTRACT

This research investigates the incorporation of the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Empowerment Theory into a robust construct within a Partial Least Squares-Structural Equation Model (PLS-SEM). Utilizing a cross-sectional survey approach, the study focuses on selected rural communities of Northern Ghana. The research encompasses 613 respondents, with an initial pilot study involving 80 participants. The study yields notable findings, establishing statistically significant and positive correlations between empowerment and attitude within the rural Ghanaian context. Furthermore, it identifies a significant influence of purchase intention on the propensity to recommend renewable energy technologies among rural households. These outcomes align with the principles of the Empowerment Theory and are in congruence with the United Nations Sustainable Development Goals (UN-SDGs), particularly SDG-7 (universal access to energy) and SDG-12 (responsible production and consumption). The study's implications extend to policy recommendations, specifically tailored to the unique energy landscape of Ghana. These findings contribute to a deeper comprehension of renewable energy proliferation dynamics and emphasize their crucial role in advancing sustainable development objectives and fostering responsible energy practices.

1. Introduction

Energy remains a crucial determinant of economic and social development because of its indispensable contribution to quality human development and technological advancement [1]. Global objectives on sustainable development like the Millennium Development Goals (MDGs) are fundamentally linked to energy consumption, since their accomplishment hinge on the successful increased and decreased consumption of certain energy sources [2]. However, the vast inequality in developed and developing energy consumption is apparent, as in most developing economies equal access to energy sources like electricity is still a dream for many citizens [3,4]. Due to the huge cost required to transition to clean energy sources, the goal of universal renewable energy consumption has become unrealistic [5,6] (see Fig. 1).

Most rural communities rely on unclean and non-renewable energy sources mostly fossil energy sources (firewood, kerosine, palm kernel, cow-dung) [7]) and this trend has no end in sight for many developing countries. These unclean energy sources aside being costly, they pose numerous health and environmental consequences to rural communities primarily involved in their use [8–10]. Most common among these consequences include environmental degradation and air pollution (both indoor and outdoor), which causes various ailments mainly respiratory in nature [8]. Thus, developing countries must maximize the utilization of clean energy to trade-off the energy needs of rural communities.

Ghana has initiated moves to transition toward renewable energies generation to augment its acute energy insufficiency. With hopes of emulating countries like Norway and Iceland who are almost fully reliant on renewable energies, Denmark will complete their transition to renewable energy by 2050 [11]. Ghana's renewable energy generation currently stands at 0.03% at its national generation mix, mainly being small solar home systems and household biogas based on installed capacity (Ghana Energy Ministry, 2021). Thus, these small renewable sources like the solar home systems for now are the beacon of hope for

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renewable energy expansion for households. Over the past few years households and business alike have faced severe energy crisis, and this has worsened the reliance on fossil fuel sources like diesel-petrol-powered generators [12]. Besides the environmental challenges, these energy sources have proven to be costly which puts additional production and transactional costs on businesses and households respectively [13]. This development is an obvious indication that there is the need to reconsider a serious approach to expanding clean energy generation and use. The government has implemented several stimuli and incentives to drive investments into renewable energy production. However, these actions may not prove successful if we do not know what could motivate renewable energy consumption. Particularly, household consumption behaviour is linked with other behavioural indicators like purchase and recommending intentions. Further, renewable energy technology use, like any other technology, is most likely to follow a usage pattern, thus it is imperative to understand what factors would drive the expansion of renewable energy technology use among locals in order to make appropriate and timely decisions to drive the transitioning to renewable energy sources.

The slow pace of renewable energy technology adoption in developing economies is attributed to several reasons, spanning from lack of policy regulation to household awareness and empowerment reasons [5].

Previous examinations on drivers of renewable energy technology use have employed different theoretical views particularly technology adoption models like TAM, TRA, TPB [14]. Employing only, these adoption related theories may not offer a complete and strong basis for understanding the factors that explain intentions to use renewable energy. For instance, Zahari and Esa [15] used the TRA to explain intentions to use renewable energy, Kardooni et al. [16] employed the TAM and Alam et al. [17] employed an integration of the TAM, TRA, TBP and the UTAUT to explain user intentions to recommend renewable energy use. Developing a suitable framework on renewable energy use is an ongoing challenge for researchers due to the varied nature of factors that can explain this phenomenon. Thus using adoption theories alone may not be enough if our goal is to assess the specific factors that drive renewable energy expansion. Masukujjaman et al. [5] recommends that it is important to draw on other theoretical views to determine other important antecedents of renewable energy use intentions. Citizenry empowerment has been highlighted as a crucial indicator for participation and engagement decisions [14]; however, its relevance to renewable energy use decisions has barely been explained. Hence, an analysis of the perspective of empowerment in decision to use renewable energy may bring fresh valuable insights on renewable energy use indicators.

Households are the least unit of economic analysis; thus, they are likely to offer important micro-level insights into the specific determinants of renewable energy technology use. They also constitute the greater proportion of consumers of energy generated [18], therefore identifying the underlying mechanisms driving renewable energy technology expansion at this level will help in shaping policy interventions that will emphasize the perceptions, attitudes, and expectations of users [19]. Much empirical evidence exists on urban household's renewable energy technologies use behavior [20,21]. However, literature on the use and diffusion behaviour jointly assessed show truly little evidence on this dimension, especially from rural households [20]. Much of renewable energy studies have focused on macro-level socio-economic factors using various econometric models. The handful of micro-level examinations focused on urban households, however, also fail to address the issue of unit-specific factors such as psychological empowerment, attitude, and behavioural elements crucial to renewable energy technology use [5,22].

The variations in demographics, economics, and behaviors between rural and urban communities underscore the imperative for context-specific investigations, as demonstrated in this study. Moreover, beyond existing studies at different analytical levels, this research strives to yield crucial insights into the determinants of renewable energy technology adoption and diffusion across all levels.

Within the unique context of sub-Saharan Africa, particularly in Ghana—an emerging economy aiming to achieve 10% renewable energy generation since 2006, by 2020 has achieved less than 1% of this goal (Amuzu-Sefordzi, 2020). In spite of the policy interventions to revive renewable energy production year-in, year-out, most renewable energy technology projects are often internationally or privately funded projects. Moreover, despite about 90% access to grid electricity across urban and rural communities, the Ghana still struggles significantly with electricity generation deficits. Thus, this study assumes paramount significance. It promises to provide evidence of the factors propelling the growth of renewable energy technologies across households in Ghana and related African states.

To achieve this, our research integrates the Unified Theory of Acceptance and Use of Technology (UTAUT) with the Psychological Empowerment Theory. This combined framework seeks to unravel how these theories influence the utilization and recommendation intentions of rural households regarding renewable energy technologies.

This study contributes significantly to the theoretical and practical knowledge on the expansion of renewable energy technology. Firstly, it pioneers the integration of the Empowerment Theory into the renewable energy literature—an aspect largely overlooked by previous examinations. This integration offers compelling evidence that a sense of

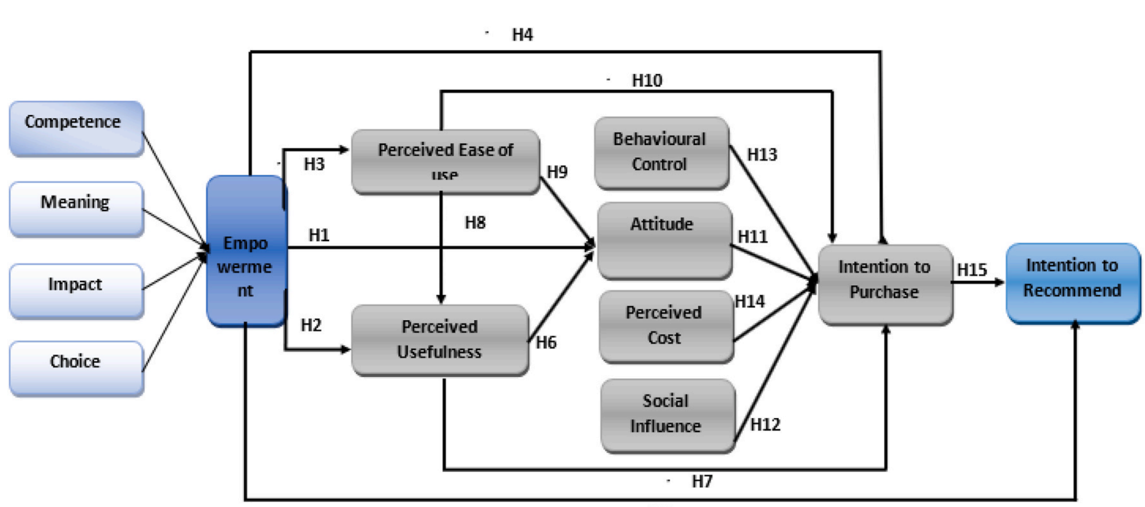

Fig. 1. Model for the purchase and recommendation intentions of renewable energy technology.

empowerment within households can strongly indicate intentions to both adopt and recommend renewable energy technology.

Secondly, by introducing the empowerment construct, firmly rooted in the Empowerment Theory, our study presents a novel framework that harmonizes this theory with the existing UTAUT framework within the renewable energy literature. Through this comprehensive analysis, we unveil the specific psychological empowerment factors capable of driving intentions to utilize and advocate for renewable energy technology.

2. Literature review and hypotheses statement

2.1. Theoretical and empirical review

Several studies have employed different theoretical models to predict behavioral intention of specific users. These often include the technology acceptance model (TAM), theory of reasoned action (TRA), theory of planned behavioural action (TPB), unified theory of acceptance and use of technology (UTAUT) etc [23,24]. Most of these theoretical models complement each other. For instance, the TPB is known to be a subset of the TRA to compliment the TRA's limitation of the variable perceived control [25]. Likewise, the TPB, in an attempt to be made more parsimonious, leaves out the external variable in the TAM, hence the difference. TAM is also widely criticized to have too many variations making it lose its parsimony [26]. Studies establish distinct differences between behavioural intention and purchase intentions based on product differences such as capital-intensive goods and consumer goods [27]. Purchase decisions are often one-time acts embodied in behavioral intentions just like a user adopting a technology they perceive has little or no cost. Thus, these theories sufficiently predict behavioural intentions, but does little to explain purchase intentions, in particular when linked with the high capital-intensive nature of renewable energy expansion. To form purchase intentions, the user needs sufficient knowledge, awareness, and be empowered to make the purchase [5].

Our review of extant studies reveal the existence of several examinations of behavioural and purchase intentions of clean energy products, particularly solar water heaters, household biogas use. For instance, Wang et al. [21] examined biogas technology use in Pakistan and found consumer electiveness, attribution to responsibility, consequential awareness, and environmental consequences, determined farmers' intentions to adopt clean energy technologies. A similar consideration in Shakeel and Rahman [22] also observed behavioral control, individual norms and cost all affect solar energy use. However, Shakeel and Rahman found awareness and knowledge of environmental concern to play insignificant roles. Relative to understanding factors that impact the adoption of biogas energy plant in Bangladesh, Kabir et al. [28] studied household income level, family size, age, education attainment and economic source of income (e.g. cattle). Kabir et al. showed that the higher the educational attainment of a household, the higher the likelihood to use biogas technology.

Even in the context of fast developing economies like China, India, Russia, Bangladesh, and Brazil, transitioning to cleaner energy sources has proven to be particularly challenging. For instance, in China, determinants of clean energy use among household units included government incentives, attitudes, household innovativeness and ecological lifestyle of household [20]. Whereas in India, social beliefs, price value, effort-expectancy, environmental concern, and hedonic motivation were factors that effectively predicted households' intention to use clean energy [29].

Furthermore, scholars have applied different theoretical perspectives to understand user intentions to purchase renewable energy. These perspectives have offered valuable insights into the varied basis for explaining households' acceptance of renewable energy technology. For instance, the TRA, employed in Zahari and Esa [15] showed intentions to use renewable energy technology, is formed on the user's perceived gains and subjective norms, whereas knowledge and environmental concern were invalid from this point of view. From a TAM perspective, Kardooni et al. [16] showed that cost, attitude, perceived usefulness, and knowledge sufficiently explained intentions to use renewable energy. Subsequently, Alam et al. [17] combined elements from the TAM, TRA, TBP and the UTAUT theories and determined that the cost, behavioural control, relative advantage, and awareness effectively explained users' intentions to use renewable energy technology.

2.2. Hypotheses development

2.2.1. Psychological empowerment

According to the psychological empowerment theory, empowerment serves as the connecting link between an individual's sense of competence, their desire for, and their willingness to engage in a particular action [30,31]. This theory has predominantly found its application within organizational settings, where it elucidates individual motivations in the workplace. Consequently, scholars like Ergeneli et al. [32] have endeavored to grasp the connection between trust in managers based on cognition and the psychological empowerment of subordinates. Simultaneously, Hochwalder and Brucefors [33] have explored the relationship between psychological empowerment and well-being in various work environments.

Despite the widespread use of psychological empowerment theory across diverse organizational contexts, it has, to the best of our knowledge, remained relatively unexplored within the domain of renewable energy technology. Psychological empowerment is typically considered in four dimensions: impact, self-efficacy, meaning, and choice [34]. Consequently, in this model, the influence of empowerment is assessed as a second-order construct on attitudes, perceived ease of use, and perceived usefulness.

The core components of psychological empowerment, as defined by their first-order constructs, are as follows:

a. Self-efficacy denotes an individual's belief in their ability to perform fundamental tasks related to managing the use of renewable energy technology at home with confidence and skill [35]. For instance, ensuring that solar panels function at peak capacity by performing simple maintenance tasks like quick rinses or surface cleaning.
b. Impact measures the extent to which an individual's decision regarding the use or recommendation of renewable energy is perceived as an action likely to influence other households to make similar choices [35,36]. For example, if a household's decision to use renewable energy technologies subsequently inspires community projects in the same vein.
c. Meaning gauges a household's subjective assessment of the value associated with the decision to adopt renewable energy [35]. For example, if there is a discussion within a community concerning projects related to renewable energy technologies, members of a household are more inclined to participate in such discussions.
d. Choice, sometimes referred to as self-determination, reflects an individual's perception of their causal responsibility for the outcomes stemming from the use of renewable energy technology [35,37]. For instance, when an individual proposes a community project that employs renewable energy technology, they feel a sense of ownership over that project. This, in turn, fosters a greater sense of involvement and empowerment among the people involved.

Psychological empowerment plays a pivotal role in enhancing individuals' competence in both the technical and environmental aspects of technology adoption. In the technical dimension, this encompasses their comprehension of usability, ease of use, and associated risks, all of which significantly influence their overall satisfaction with renewable energy technology. On the other hand, the environmental dimension involves their understanding of the ecological impact and environmental consequences associated with the use of such technology. Therefore, fostering psychological empowerment within households is crucial for deepening their comprehension of the benefits and repercussions of clean energy technology, thereby imbuing the benefits with greater significance.

By empowering individuals with technical and environmental awareness, we pave the way for the formation of positive attitudes, as evidenced by studies highlighting knowledge and awareness as powerful tools for empowerment [38]. Moreover, these studies have unveiled positive correlations between knowledge and acceptance of technologies like hydrogen and wind power [39]. This suggests that the empowerment theory contributes significantly to advancing theoretical understanding in the realm of technology adoption, and as such, it is poised to elucidate behavior both before and after the adoption of technology. Consequently, we formulate the following hypotheses.H1 – H5. Psychological empowerment positively impacts attitude, perceived usefulness, perceived ease of use, intention to use and intention to recommend renewable energy technology.

2.2.2. Perceived usefulness

A user's subjective belief that a particular product enhances their well-being is termed as their perceived usefulness of the product, as defined by Davis [24]. When it comes to households utilizing renewable energy technologies such as biogas or solar power, they may perceive these sources as offering comparative advantages over conventional fossil fuels like coal and firewood. The decision to adopt renewable energy technology may hinge on whether households believe that it leads to improved safety, financial savings, environmental benefits, and an enhanced societal status compared to existing conventional alternatives.

In the context of this study, it is posited that these advantages are not solely evaluated in comparison to current energy sources but also with a forward-looking perspective, that considers the well-being of future generations. Scholarly literature underscores that the stronger the perception of a technology's usefulness, the higher the likelihood of its acceptance, and the more expedited the decision-making process to acquire and implement that technology [40]. Building on this foundation in the literature, we formulate the following hypothesis.

H6–H7. Perceived usefulness positively affects attitude and intention to purchase.

2.2.3. Perceived ease of use

Perceived ease of use is how an individual views the simplicity of operating a particular technology and how skilled they are in doing so [24]. Households are likely to develop positive attitudes toward using renewable energy technologies if they find it friendly to operate [41,42]. This is essential, particularly in areas of understanding and maintaining an unfamiliar technology before deciding to acquire it. Perceived usefulness and Perceived ease of use relate directly as antecedents explaining attitude and behavioural intentions [43,44]. Hence, ceteris paribus, households have greater likelihood of perceiving renewable energy technology as more valuable if they perceive it as a technology easy to use [45]. Based on the aforementioned, we hypothesize that:

H8–H10. Perceived ease of use positively affects attitude, perceived usefulness, and intention to purchase.

2.2.4. Attitude

Prior studies position attitude as those desirable or undesirable subjective views households hold about renewable energy use, thus it is employed as a determinant of household intentions to use renewable energy technology. Households' perceived usefulness and ease of use of renewable energy technology affects their attitude. Prior examinations determine that attitudes positively affect user intentions to use a new technology [46]. Thus, in line with prior studies, we hypothesize that:

H11. Usage attitude of households positively affects renewable energy use intentions.

2.2.5. Social influence

Social influence in technology adoption is elucidated by the simulation of an individual's actions or decisions, which are shaped by the beliefs and opinions held within their close social networks. This phenomenon finds its roots in the work of Fishbein and Ajzen [23]. For example, when an individual observes their neighbors, family members, and friends embracing renewable energy sources, they are likely to receive recommendations and advice to follow suit. A substantial body of scholarly research consistently highlights a positive relationship between social influence and behavioral intentions [47–51].

Based on this foundation in the literature, we propose the following hypothesis.

H12. Social influence positively influences households' intentions to use renewable energy technology.

2.2.6. Behavioural control

Perceived behavioral control, as described by Han et al. [45], represents the perceived ease or difficulty of undertaking actions or interventions in various situations. It is influenced by a user's belief in their accessible control and their awareness of potential challenges and opportunities. This concept also encompasses an individual's need for factors that facilitate the achievement of positive outcomes, as emphasized by Chang [52]. Therefore, when it comes to making investments in costly technologies such as renewable energy, certain conditions must exist to favorably facilitate this decision.

For instance, a user's comprehension of how to utilize the technological tools, access to reliable assistance for regular maintenance and other activities, as well as the availability of resources and replacement parts, can serve as facilitating conditions [53]. Even if an individual lacks expertise, if they believe they can readily access help or acquire necessary resources and parts, they are more inclined to opt for the technology—in this case, renewable energy technologies. Research by Shaheen et al. [54] has demonstrated the effectiveness of perceived behavioral control in explaining user actions and intentions. Furthermore, studies such as Alam et al. [17], Shakeel, and Rahman [22] provide additional empirical support for the positive relationship between behavioral intent and perceived behavioral intentions.

Drawing from this body of research, we formulate the following hypothesis.

H13. Perceived behavioural control positively affects intentions to use renewable energy technology.

2.2.7. Perceived cost

Cost considerations hold significant sway over purchase and usage intentions, particularly when the product in question deviates from the usual consumer goods, as is the case with renewable energy technology. The decision to acquire renewable energy technology necessitates a thorough evaluation of factors such as quality, reliability, and cost alternatives. This concern remains pertinent even at the national level, where governments grapple with investment decisions regarding renewable energy production.

In alignment with this perspective, research at the individual level, as exemplified by Faiers and Neame [55], underscores the pivotal role of cost considerations in shaping households' decisions to adopt solar power in the UK. When costs are perceived as high, households exhibit reduced interest in the technology. Cost-related elements encompass aspects like the overall cost of acquisition, installation expenses, and maintenance and repair costs [17].

Scholars have suggested that high costs can act as a deterrent, either postponing or diminishing the desire to purchase a product [56]. Additionally, it can reduce the inclination to recommend its usage to others [57]. These insights lead us to formulate the following hypothesis.

H14. Perceived cost negatively affects intentions to use renewable energy technology.

2.2.8. Purchase intention

Purchase intentions, as described by Dodd and Supa [58], represent an individual's likelihood of acquiring a product. This concept has been established as a reliable determinant of future actual purchase decisions [23,58–60]. In many studies, technology adoption assessments typically conclude upon determining purchase intentions, as it is widely accepted as the final and dependable measure of actual purchase decisions [23, 61].

However, this study ventures beyond the conventional approach by positing that purchase intentions can also serve as a catalyst for recommendations to other potential clients. This unique perspective aims to foster the growth and rapid advancement of renewable energy technology—a relatively infrequent exploration in the technology acceptance literature. Given the pressing need to achieve global sustainability goals and reduce reliance on environmentally detrimental unclean energy sources, purchase intentions are seen as a potential driver for the widespread adoption of renewable energy technologies.

Furthermore, since individuals do not frequently purchase renewable energy technology, this model extends its applicability to assess its usefulness in facilitating recommendations for purchases by other households. Thus, this model becomes relevant not only for one-time purchases but also for products that can be repeatedly acquired.

H15. Purchase intentions positively affects intentions to recommend renewable energy technology to other households.

2.2.9. Intention to recommend

Recommendation intent has nascently been studied due to the much greater focus on use behaviour. Few studies like ([14]; Milten et al., 2013; Lee et al., 2011) that have assessed this relationship agree that users have greater desire to recommend a technology to others when they possess greater intentions to use the technology themselves. The goal behind hypothesizing an effect on intention to recommend is that, when households possess an intention to use renewable energy technology, they may also have interest in other households with similar interests to use this technology. Thus, the behaviour recommending the technology may aid in the propagation of clean energy development. Since the use of renewable energy technology implies a household already sufficient awareness and understanding of the benefits and consequences, offering recommendations is another favourable step toward the transitioning goal. It is also crucial to know that, transitioning to renewable energy sources will be successful in the long run only with sufficient number of users subscribe to using them.

3. Methodology and data

Renewable energy development is transitioning from being techno-economic focused to understanding how users and institutions or society in general can affect the development process (Amuzu-Sefordzi, 2020). Thus, this study is designed to examine contemporary strategies for renewable energy technology acquisition and proliferation in rural Ghana.

This empirical study was conducted in certain rural communities in Northern Ghana, where major renewable energy technology projects are undertaken by the state energy agency. The research sample consisted of 613 respondents, including an initial 80 respondents involved in a pilot study. According to Schriesheim et al. (1993), a pilot study typically involves 65 participants, while a minimum of 200 respondents is considered sufficient for a full-scale empirical study (Hoelter, 1983). The study employed a random sampling technique to select participants. Notably, the rural households included in the data collection were mostly non-users of any form of renewable energy technology but had access to electricity. The data collection spanned over a period of 6 months (April–October 2022) and involved the use of a 7-point Likert-scale questionnaire to gather responses from the households.

The initial questionnaire initially comprised 51 items adapted from relevant literature, but only 35 items were retained in the final instrument. This selection was based on a criterion of item loadings of 0.70 or greater, ensuring reliability, as determined through an exploratory analysis of the pilot data using Smart PLS. All 14 constructs in the model exhibited satisfactory validity and construct reliability, with alpha and Rho A values ranging from 0.70 to 0.87 and 0.70 to 0.90, respectively. Additionally, the Average Variance Extracted (AVE) values exceeded the threshold of 0.50, and Composite Reliability values were well above 0.70 for all constructs (refer to Table 2). The final quality criterion assessed was discriminant validity, which was established through the Fornell-Larker criterion, demonstrating adequate discriminant validity among the construct items. Consequently, the study provides a robust foundation for further analysis of the structural model. The SmartPLS 3 software was employed for bootstrapping estimations and structural model path estimations.

4. Results and discussions

This section begins with showing the demographic details of the households, then the structural model assessment will be discussed.

4.1. Demographic description

From the total respondent population used for this study, 71.33% and 28.67% were female and male respectively and majority (54.8%) of the respondents were within the 39–48 age bracket. Only about 6% and 19% of these respondents represented those between ages 18–28 and 29–38 respectively and 9.6% were within 59> category. Majority (71.7%) had no education, while 17.3% had basic school education. The least (3.9%) was university education and (7.1%) had secondary school education. The majority (87.3%) were engaged in farming and 10.9% engaged in trading farm produce and transport business (1.8%). Most (48.3%) of these households are within the Ghc 700–1400 (100$ - 200 $), while only 6% was above 3500 ($500) monthly income.

4.2. Model justification and evaluation

The study's model was empirically examined using a structural equation model, specifically employing a partial least squares estimation procedure. This estimation model is well-suited for evaluating statistical models designed to provide causal explanations [62]. Partial least squares (PLS) estimation is commonly employed in causal relationship studies because it enables the analysis and measurement of relationships between predictor and outcome variables. The PLS estimator is particularly advantageous in testing causal relationships, making it the preferred choice for this study. It offers the flexibility to relax restrictions on measurement scales, sample size, and residual distributions, making it suitable for testing and exploring new theories, as is the aim of this study.

In assessing the psychometric properties of the PLS-SEM, it is crucial to evaluate the measurement items for reliability before proceeding with model estimation. Hypothesized relationships are then examined to ensure the structural model's validity. In the current analysis, the adequacy of individual construct items was assessed through various metrics, including internal consistency (Alpha and Rho A) estimates, composite reliability (CR), average variance explained (AVE), and inter-construct correlations (refer to Table 1).

As summarized in Table 2, reliability estimates for composite reliability, Cronbach's alpha, and Rho A were all found to be at least 0.70 or higher. The estimates for Average Variance Extracted (AVE), which indicate the proportion of variance explained by the indicators relative to measurement error, were all comfortably above the 0.50 threshold. These results justify the inclusion of all evaluated constructs in the structural model. According to Hair et al. [63], CR, Alpha, and Rho_A

Table 1
Inter-item correlations (discriminant validity assessment) and reliability estimates.

#	Construct	1	2	3	4	5	6	7	8	9	10	11	12	13	Cronbach's Alpha	Rho_A	CR	AVE
1	Attitude	**0.9**													0.74	0.77	0.93	0.81
2	Competence	0.54	**0.79**												0.70	0.70	0.83	0.62
3	Empowerment	0.70	0.65	**0.88**											0.87	0.88	0.91	0.77
4	Impact	0.41	0.72	0.48	**0.88**										0.73	0.79	0.88	0.78
5	Intention to Purchase	0.22	−0.04	0.05	−0.01	**0.81**									0.75	0.77	0.85	0.65
6	Intention to recommend	0.18	0.05	0.07	0.05	0.68	**0.82**								0.76	0.78	0.86	0.68
7	Meaning	0.05	0.05	0.04	0.04	0.00	0.05	**0.86**							0.86	0.90	0.90	0.75
8	Perceived ease of use	0.75	0.74	0.71	0.58	0.04	0.08	0.03	**0.77**						0.71	0.73	0.81	0.60
9	Behavioral control	0.14	−0.01	0.02	0.03	0.63	0.73	0.05	0.01	**0.79**					0.80	0.85	0.83	0.63
10	Perceived cost	0.24	0.11	0.22	0.10	0.49	0.56	0.07	0.15	0.49	**0.90**				0.70	0.77	0.93	0.80
11	Perceived usefulness	0.76	0.62	0.73	0.52	0.03	0.05	0.05	0.75	0.00	0.18	**0.82**			0.75	0.77	0.86	0.68
12	Self determination	0.49	0.78	0.58	0.73	−0.05	0.02	0.06	0.65	0.02	0.07	0.61	**0.81**		0.70	0.77	0.85	0.66
13	Social influence	0.18	0.02	0.07	0.06	0.74	0.77	0.04	0.08	0.70	0.58	0.03	0.02	**0.78**	0.80	0.80	0.82	0.61

estimates ≥ 0.70 and AVE estimates > 0.50 are sufficient for further analysis. Additionally, discriminant validity was assessed through inter-construct correlations using the Fornell-Lacker criterion. This criterion involves comparing the square roots of the AVEs with construct correlations. It was observed that the square roots of the AVEs (highlighted on the diagonals) were greater than the construct correlations both horizontally and vertically in the matrix. This confirms discriminant validity among the constructs.

An assessment of multicollinearity between the construct item indicators was done using the VIF estimates, summarized in Table 2. VIF estimates 3 and over indicates greater correlations between items and this is an indication of problematic items loading highly on other constructs [64].

4.3. *Structural model assessment*

The validity of the outcome and predictor variables for was of crucial importance to the structural model assessment. Relative to the soundness of the criteria 35 measurement items were verified. Hypothesized path relationships, which determined whether a hypothesis is accepted or rejected, is the main reason for the structural model assessment phase.

The results observed in this study (in Table 3) suggest that there were statistically significant and positive associations between empowerment and attitude ($\beta = 0.194$, $p < 0.04$), empowerment and perceived usefulness ($\beta = 0.274$, $p < 0.007$), empowerment and perceived ease of use ($\beta = 0.392$, $p < 0.000$), empowerment and intention to recommend ($\beta = 0.350$, $p < 0.000$). The other hypothesized relationships between perceived usefulness and attitude ($\beta = 0.344$, $p < 0.000$), perceived usefulness and purchase intentions ($\beta = 0.255$, $p < 0.017$), perceived ease of use and perceived usefulness ($\beta = 0.750$, $p < 0.000$), perceived ease of use and attitude ($\beta = 0.358$, $p < 0.000$), social influence and intention to purchase ($\beta = 0.546$, $p < 0.000$), perceived behavioural control and intention to purchase ($\beta = 0.192$, $p < 0.002$), perceived cost and intention to purchase ($\beta = 0.164$, $p < 0.030$) were also found significant. In addition the intention to purchase also significantly influenced intentions to recommend renewable energy technologies among the rural households ($\beta = 0.683$, $p < 0.000$). In this regard the analysis supports twelve hypotheses (H_1, H_2, H_3, H_5, H_6, H_7, H_8, H_9, H_{12}, H_{13}, H_{14}, and H_{15}) and three (H_4, H_{10}, and H_{11}) are unsupported.

4.4. *Discussion of findings*

The initial hypothesis proposed that psychological empowerment would ultimately influence attitudes that would eventually influence purchase intentions. Thus, the findings validate this proposition. In essence, rural consumers' positive attitudes toward renewable energy

Table 2
Multi-collinearity assessment with Variance Inflation Factor (VIF).

Items	VIF	Items	VIF
ATT1	1.233	INUSE4	1.012
ATT2	1.026	PBC2	1.238
ATT3	1.481	PBC3	1.491
EMPR2	2.519	PBC4	1.335
EMPR3	2.846	PC1	1.481
EMPR4	1.258	PC3	1.512
IMP1	2.731	PC4	1.490
IMP2	2.944	PEOU1	1.196
IMP3	1.781	PEOU2	1.991
INREC1	1.632	PEOU3	1.012
INREC2	1.775	PEOU4	1.334
INREC3	1.351	PUSE1	2.159
INREC4	1.124	PUSE2	2.160
INSUE2	1.124	PUSE3	1.191
INUSE1	1.166	PUSE4	1.439
INUSE3	1.166	SOCIN2	1.323
INUSE3	1.004	SOCIN3	1.393
		SOCIN4	1.293

Table 3
Bootstrapped estimates.

	Path	Coeff.	T-stats	P-value	Conclusion
	Competence - > Empowerment	0.510	6.346**	0.000	Supported
	Meaning - > Empowerment	−0.002	0.047	0.962	Not supported
	Impact - > Empowerment	−0.034	0.483	0.629	Not supported
	Self-determination - > Empowerment	0.206	2.350*	0.019	Supported
H1	Empowerment - > Attitude	0.194	2.912*	0.004	Supported
H2	Empowerment - > Perceived Usefulness	0.274	2.491*	0.007	Supported
H3	Empowerment - > Perceived Ease of Use	0.392	6.244**	0.000	Supported
H4	Empowerment - > Intention to Purchase	0.130	1.737	0.083	Not supported
H5	Empowerment- > Intention to Recommend	0.350	5.949**	0.000	Supported
H6	Perceived usefulness - > Attitude	0.344	5.848**	0.000	Supported
H7	Perceived usefulness - > Intention to Purchase	0.255	2.651**	0.017	Supported
H8	Perceived ease of use - > Perceived Usefulness	0.750	33.35**	0.000	Supported
H9	Perceived ease of use - > Attitude	0.358	6.062**	0.000	Supported
H10	Perceived ease of use - > Intention to Purchase	0.132	1.377	0.072	Not supported
H11	Attitude - > Intention to Purchase	0.174	1.491	0.137	Not supported
H12	Social influence- > Intention to Purchase	0.546	9.155**	0.000	Supported
H13	Perceived behavioral control - > Intention to Purchase	0.192	3.144**	0.002	Supported
H14	Perceived Cost - > Intention to Purchase	−0.164	2.216*	0.003	Supported
H15	Intention to Purchase - > Intention to Recommend	0.683	21.872**	0.000	Supported

technology highly correlates with the extent of knowledge about the technology. In essence, the rural consumers a more likely to form positive attitudes towards renewable energy technology if they feel empowered about using them.

There was no significant correlation between empowerment and intentions to acquire renewable energy technology. This stands in stark contrast to some earlier studies including [50,65–68] and the initial proposition of this current study.

It is conceivable that households possessing only limited familiarity and insight into renewable energy technology might exhibit a propensity to abstain from acquiring energy products perceived as foreign or unfamiliar. Another, plausible explanation for this phenomenon could be attributed to potential limitations in our field study, which may not have adequately facilitated a comprehensive comprehension of renewable energy technology or nurtured the psychological empowerment necessary to drive purchase intentions.

The results further show that empowerment significantly relates with intentions to recommend renewable energy technology, meaning that with adequate attitudes that drive purchase intentions, rural consumers will also recommend renewable energy technology. This finding aligns with [69–72] who revealed that user efficacy positively influences various actions. Like established in this study, the results showed that empowerment positively influenced usefulness and perceived ease of use. Thus, just as empowerment can be linked with decisions to recommend renewable energy technologies, likewise, empowerment significantly connects with perceived usefulness and ease of use of renewable energy technology, either for its pro-environmental benefits or the technical usefulness. Lower efficacy and lack of understanding about renewable energy technology use and the good it does to the environment is detrimental to usage and acceptance decisions of rural consumers.

Further determined in this analysis is the fact that the usefulness perception of renewable energy technology is improved through empowerment, which tend to be favourable for purchasing renewable energy technology decisions. According to Hwang, (2009) perceived utility of solar powered clothing influenced users purchase decisions. Similarly, when rural consumers perceive the constructive benefits of renewable energy sources over conventional energy sources, the knowledge and empowerment acquired is enough to drive renewable energy acquisition. In addition, in Ko et al. [73] and Chae [74] observed perceived usefulness to influence buying attitude of smart clothes. These studies in addition to this current one endorse the nexus between perceived usefulness and purchase intentions for renewable energy technology. The greater the perceived utility of renewable energy the greater the likelihood to acquire them for use.

Perceived ease of use, in this study, established an insignificant relationship with purchase intentions of renewable energy technology. Although the intention to purchase is not influenced by the perceived ease of use, ease of use was significantly influenced by empowerment. The insignificant influence of perceived ease of use on purchase intentions could be explained in the following ways. First, unlike other technologies like software programmes, renewable energy technology, although technical do not require much technical expertise or professional training for the end user. In addition, households know that the supplier would do maintenance and repairs of renewable energy technology sources even after acquiring the technology.

Moreover, perceived ease of use also exerts a strong positive effect on perceived usefulness of renewable energy technology. By implication, greater empowerment on the technical ease of use aspects drives usefulness perceptions. When rural households perceive or understand the operation of renewable energy technology components to be easy, it is likely to increase their positive outlook of renewable energy technology. This finding is consistent with the conclusions of Shakeel and Rahman [22] and, Halder et al. [75].

Furthermore, perceived usefulness and perceived ease of use both increase positive attitudes toward purchase intentions. In other words, attitudes towards renewable energy use positively relate with consumers' subjective views of usefulness and ease of use. Consequently, the desire to ultimately purchase or not purchase renewable energy technologies significantly depend on the extent to which a consumer feels secure with renewable energy technology use [76].

Finally, our findings also reveal that purchase intentions positively relate with cost, in that, a higher perceived cost, the lower the likelihood to purchase them. This negatively hypothesized relationship showed that among the rural households the degree to which higher cost is perceived, reduces the likelihood to purchase renewable energy technologies. Alam et al. [17], in line with this finding found a moderate influence of cost on small-scale utilization of renewable energy technology. Relative to solar power acceptance, Kim et al. [77] revealed a negatively significant link with cost and acceptance decisions.

5. Theoretical and practical implications

5.1. Practical implications

As part of efforts to create awareness, some organizations make efforts to provide training for consumers to fulfill the purpose of self-service and ease of use renewable energy technologies. However, these efforts are limited to certain category of consumers, mostly existing clients. Relative to prospective clients of renewable energy technologies, such training and awareness programmes are not available in any way from manufacturers, suppliers, or distributors, and or government agencies. The few available training programmes are often technical in nature, mostly on aspects of installation, maintenance, or replacement for persons desiring to ply a trade in supplying and installing renewable energy technologies. A structured training program required to create awareness for the benefits (both health and environmental) and risks to consumers is completely missing. Other means of increasing public awareness of renewable energy technologies among households could be through mass communications media and advertisements. There has been little evidence of this kind of approach (advertising and mass communicating benefits and risks) by companies or state bodies to publicize renewable energy technologies in Ghana. Rather, most of the companies who attempt these training programmes employ posters, direct sales techniques, and word of mouth references to engage clients for such purposes. Although these approaches work satisfactorily, they are not effective enough to reach the broader public. Further, the growing use of social media and other new media modes of communication and advertisement could prove additional options to drive the awareness of renewable energy technologies among households in Ghana. Besides, many rural folks use smart devices and social media. The crucial role of psychological empowerment is clearly observed in this study. Empowering through introducing them to various choices of renewable energy technologies and providing relevant information that increases their competence with understanding the usefulness, ease of usability, health and environmental benefits of these technologies will largely improve the positive attitudes towards renewable energy technologies for household use.

Social influences are observed as a predictor of purchase intentions of renewable energy technologies, much like observed in other previous studies. Given this finding, and the result that purchase intentions tremendously influenced intentions to recommend renewable energy technologies, companies and state bodies can leverage on the social networking technologies to create awareness of small-scale renewable energy utilization among households, while employing the power of social influence to drive usability. Further, it was observed that perceived cost is an important predictor of user intentions to purchase renewable energy technologies. From field interactions, the researchers observed that the cost of acquiring renewable energy technologies for an entire household is a key determining factor dragging the expansion of renewable energy technologies among rural households. In Ghana, installing a 1 KW (120 per watt) solar system for a home unit with batteries currently costs about Ghc 15, 200 ($2000). This is almost four times the average income levels of the rural consumers. Thus, prospective consumers of renewable energy technologies, particularly solar home systems have withdrawn due to the costly nature of the technology. Further, additional cost like installation or maintenance cost deters many household consumers. While some suppliers offer free installations, others, such biogas energy providers charge quite significant amounts. From this households perceive that they will be paying much more for the renewable energy products. Suppliers, companies, and state agencies seeking to drive the increase acceptance and use of renewable energy technologies must consider pricing mechanisms for such communities like those in the rural areas in order to attract rural consumers in this sector.

5.2. Policy implications

This study provides valuable insights for policymaking in the realm of renewable energy adoption and utilization. Firstly, local government authorities can play a pivotal role in promoting the transition to renewable energy sources by encouraging their acceptance and integration across various sectors. This could commence with comprehensive awareness programs to educate the public about the benefits of renewable energy technologies. Additionally, addressing cost-related barriers that impede the widespread use of these technologies is crucial. For instance, in Ghana, targeted initiatives like offering competitive bank financing and grants to small and medium-sized businesses could incentivize them to invest in partial self-power generation. Such measures not only promote sustainability but also reduce energy costs for businesses in developing economies.

Similar strategies can be extended to households, encouraging them to adopt renewable energy technologies for partial energy generation. This approach can alleviate the burden on the national grid and gradually transition many households away from complete reliance on centralized power sources.

Furthermore, within the context of rural electrification projects, particular attention should be paid to providing rural areas with small to medium-sized renewable energy options. Key facilities such as health centers, schools, and government offices in these regions could greatly benefit from such initiatives, enhancing access to essential services.

Addressing pricing disparities is another critical aspect of policy formulation. Governments can establish regulations to ensure market equity, determining who qualifies to sell or supply renewable energy technologies. Such regulations are essential to prevent cost-related disenfranchisement of potential consumers, thus facilitating faster adoption and utilization of renewable energy technologies.

5.3. Theoretical implications

This study not only holds implications for policy and practice but also contributes to the realm of theory by introducing and validating a behavioral model for the acceptance and recommendation of renewable energy among Ghanaian households. It offers valuable insights for researchers seeking to understand the factors influencing the preferences of rural households when it comes to renewable energy technologies. The model developed and validated in this study provides standardized and accurate measurements for purchase recommendation intentions, applicable in various contexts.

While previous research primarily focused on developed countries, this study addresses a gap by tailoring the model to the rural context of Ghana. It expands the existing model by integrating new constructs derived from relevant literature and empirical analysis. Notably, it introduces psychological empowerment and recommendation elements that were absent in the original model, offering a comprehensive approach to assessing purchase and recommendation intentions.

The study's rigorous analysis, including validity assessments and structural equation modeling, addresses limitations observed in prior studies. As such, it serves as a valuable reference point for future research, enhancing our understanding of renewable energy adoption in the specific context of Ghana.

6. Conclusion

This study investigated the factors influencing rural consumers' intentions to purchase and recommend renewable energy technologies. The research model integrated psychological empowerment, intention to recommend, and various constructs from associated theories. Findings revealed significant relationships between empowerment, usability, usefulness, attitude, and recommendation intentions. Purchase intentions were influenced by behavioral control, social influence, and cost. Attitudes had no direct impact on purchase intentions but showed indirect connections. Examining only purchase and recommendation intentions may not fully explain renewable energy adoption, especially for those not yet connected to the grid. Future research could include perspectives from stakeholders such as suppliers, manufacturers, clients, and regulatory bodies, extending beyond Northern Ghana and comparing rural-urban consumer views.

CRediT authorship contribution statement

Divine Q. Agozie: Conceptualization, Formal analysis, Methodology. **Anthony Afful-Dadzie:** Validation, Visualization. **Bright Akwasi Gyamfi:** Data curation, Writing – original draft, Investigation. **Festus Victor Bekun:** Writing – original draft, Writing, Validation, Visualization, Supervision, Corresponding.

Declaration of competing interest

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

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