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Renewable energy and innovation in Saudi Arabia: An exploration of factors affecting consumers' intention to adopt Solar PV

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ABSTRACT

Achieving 'net-zero' has become a major concern for governments worldwide. For this momentous transition to be realised, individual citizens must be motivated to adopt 'cleaner' innovative technologies to reduce their carbon footprint. Against this backdrop, our study investigates factors that may encourage or inhibit the intention to adopt renewable energy (specifically Solar photovoltaics (PV)) among home-owning Saudi consumers. Drawing on the theory of planned behaviour, we examine the relationship between demographic variables and consumers' attitudes toward renewable energy (RE) and their intention to adopt new RE technology. Our findings reveal that a lack of consumer knowledge about RE is the major obstacle to Solar PV adoption among Saudi consumers. Moreover, consumers' environmental beliefs may not lead directly to an intention to adopt RE, even though it is associated with favourable attitudes toward the technology. Finally, social influence may be crucial when promoting RE adoption among Saudi consumers. These are essential considerations for policymakers to note and act on when constructing energy policy.

1. Introduction

Increasingly strident international demands to combat climate change through a transition to a global 'net-zero' economy (Sarzynski et al., 2012; UNFCCC, 2021; IPCC, 2022) provide the context for the research outlined in this paper. Arguably, to address such challenges requires momentous societal shifts worldwide, relying on securing the awareness, knowledge, espousal, leadership, and actions of a range of actors located in the public, private, and voluntary sectors. Furthermore, if the move to a 'net-zero' economy is to be realised, it will also require cooperation and support from individual citizens and households, who as consumers, will need to be motivated to adopt 'cleaner' innovative technologies (Cowan et al., 2009; Fischer et al., 2007; Le Loarne-Lemaire et al., 2021; Park et al., 2014; Sardianou and Genoudi, 2013).

Conspicuously, in seeking to attain 'net-zero', governments across the world have chosen to explore and foster new renewable energy technologies (RES)[1] (Shrimali and Kniefel, 2011) as an alternative to traditional fossil-fuels (Menegaki, 2013; Sarzynski et al., 2012; Zhang et al., 2009). Crucially, evidence shows that some countries have made more impressive strides than others in adopting such renewable energies.[2] As recently reported (Enerdata, 2023), between 2010 and 2022, the share of renewables in the global energy mix had grown by 10 % to

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[1] Renewable energy has been defined as a 'natural source' from which energy can be taken but which is renewed more rapidly than it is used (Harjanne and Korhonen, 2019).

[2] Among the diverse types of RES currently available, solar and wind power are the most rapidly expanding sectors because they are naturally abundant, are widely perceived to be environmentally favourable, and have well-developed technologies (Munawwar and Ghedira, 2014).

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almost 30 % overall with some countries producing as much as 60 % of their electricity from renewables and several countries producing >40 % of their energy from renewables.[3]

By contrast, however, some countries that are well-endowed with appropriate natural resources, have modest records to date. One such country is the Kingdom of Saudi Arabia (KSA). KSA is a country that has a long history of involvement and investment in fossil fuels[4] (Tlili, 2015), and only a relatively limited experience of renewable energy technologies. In 2022, renewable energy accounted for only 1.1 % of the country's energy mix (Enerdata, 2023). Nevertheless, the country has begun to take important steps toward embracing renewables.[5] Moreover, as noted by Tlili (2015, p. 869) according to a United Nations report, "Saudi Arabia was ranked seventh in the world in 2012 in the list of 10 best places in clean energy worldwide", concluding that the KSA should actively exploit renewable energy (solar, wind and geothermal energy). Other studies have similarly highlighted the KSA's capacity for renewable energy (El-Sebaii et al., 2009; Rehman, 2005). Furthermore, Saudi Arabia is becoming an investment powerhouse and an economic hub linking three continents. Being a part of G20, Saudi Arabia is committed to sustainable development by leading the way toward "seizing the opportunities of the 21st century for all" while holding the presidency (United Nations, Voluntary National Reviews, 2023). Such a pledge aligns with the Saudi government's earlier policy statement entitled *Vision 2030* (Saudi Press Agency, 2016).

The circumstances outlined immediately above provoke intriguing questions about the trajectory of RES (especially solar energy) in Saudi Arabia. As a result, we chose to examine the country (and its consumers) as an important 'test case' as regards the adoption (or not) of new renewable energy technology. In order to conduct our investigation, we draw on the theory of planned behaviour (TPB) (Ajzen, 1991), probing several key factors affecting the intention to adopt RES among home-owning consumers in Saudi Arabia. For this research, we address a core research question: *What factors encourage or inhibit Saudi consumers when considering the adoption or otherwise of RES?* Deepening our analysis, we then proceed to examine the moderating impact of demographic variables on consumer attitudes toward RE and their intention to adopt new RE technology by tackling a supplementary research question: *What effect do demographic factors have on consumer attitudes regarding RE and Solar PV and their potential adoption of the innovative technology?* To gather primary data in response to these questions, we employ a self-administered online questionnaire that generated 415 valid responses.

In examining the Saudi case, our research contributes to extant scholarship in several substantial ways. Firstly, we address the empirical lacunae concerning consumer behaviour in Saudi Arabia, delving into demographic variables (such as gender, age, income, educational level, and household size) that serve as 'moderators' between 'attitudes toward RE' and the 'intention to adopt' it (or otherwise). Additionally, our work builds on and extends the corpus of research concerning the adoption of Solar PV internationally by building on previous scholarship, particularly in relation to other developing countries (see for example Irfan et al., 2021; Aklin et al., 2018a; Aklin et al., 2018b) and in relation to consumer behaviour (see for example, Asif et al., 2023; Hansen et al., 2022; Masrahi et al., 2021; Xin and Long, 2023). In so doing we use similar methods and theory as some of these other authors. However, what distinguishes our work from that of some previous studies is that we furnish authoritative data about Saudi consumers' lack knowledge about RE, revealing the latter to be a major barrier to the adoption of RE by Saudi consumers. Interestingly, we also show that Saudi consumers' environmental beliefs may not lead directly to an intention to adopt RE. Finally, and perhaps most importantly, we demonstrate that social influence is likely be the most critical factor affecting RE adoption among Saudi households, particularly since the country's population largely comprises extended families, tribes, and close-knit communities (Ochsenwald et al., 2022) where opinions are often significantly shaped and determined.

Significantly, our findings provide important lessons for public (and other) policymakers as regards the acceptance of renewable energy among consumers (Kanellakis et al., 2013). The data suggest that when governments and businesses seek to stimulate behavioural change among consumers, aiming to move toward a 'net-zero' economy, they must be cognisant of the level of awareness and knowledge among the consumers of the new renewable energy technology. Based on our data, Saudi policymakers would be well advised to provide public information and education regarding this new technology and, when targeting the population of a country such as Saudi Arabia, they should invest in more impactful channels of communication such as social media and exploit the social networks (i.e. extended families, tribes, and close-knit communities) that play such a vital role in opinion-forming in the country. Such conduits of information (and persuasion) would appear to be highly influential in determining acceptance (or otherwise) of the new renewable energy technology.

Having introduced our research, we now outline the structure of the remainder of the paper. The next section presents our conceptual model, a brief literature review, and hypotheses. Our methodology and results are then summarized followed by a discussion of the main findings and their policy implications. The closing section discusses the study's conclusions, its limitations, and potential future research.

2. Theory and hypothesis development

2.1. Theory of planned behaviour

Our research draws on long-standing, well-established, and widely used theory, namely, the Theory of Planned Behaviour (TPB) (Ajzen, 1991), a refinement to an earlier framework labelled the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980). Ajzen and Fishbein

[3] Notably, in 2022, countries with large hydroelectricity schemes such as Brazil, Colombia, Canada, New Zealand, Sweden, and Norway over 60 % of electricity was generated via renewable sources. In other countries, with targeted renewable policies and declining production costs for solar and wind energy, there has been a substantial increase in the share of renewables in the power mix. In Europe in particular, since 2010, the share of the energy supply contributed by renewables has increased by 18 % to 43 %. By 2022, the highest growth was recorded in the UK (an increase of 34 % to 43 %), the Netherlands (by 30 % to 40 %), in Germany (by 27 %. to 44 %), and in Türkiye (by 15 % to 42 %). Beyond Europe, striking rises were achieved by Australia (an increase of 22 % to 31 %), in Chile (by 14 % to 55 %), In the USA (to 22 %), China (to 31 %), Japan (to 22 %), and Thailand (to 18 %), and by 8 %. in South Africa (to 10 %) (Enerdata, 2023).

[4] Saudi Arabia has a significant level of energy usage and is traditionally heavily dependent on oil. Crucially, Saudi Arabia is the world's second largest oil producer (Tlili, 2015), relying on oil and gas for domestic consumption (Munawwar and Ghedira, 2014), burning more oil to generate electricity than any other country (Düştegör et al., 2018; Hirtenstein, 2016), and producing greenhouse gas emissions levels second only to the USA (Tlili, 2015).

[5] Observers note that Saudi aspirations for solar power production are producing concrete policies and projects (International Renewable Energy Agency, 2019). According to Collins (2021), Saudi Arabia is increasing its renewable energy production with a particular focus on solar energy. In 2019, of the 397 MW of renewable generating capacity installed in the country, 394 MW was derived from solar power. Solar PV was expected to power 40,000 homes by the end of 2023 (Yale School of the Environment, 2018). Previously, in 2018, as part of this drive, a 300-MW Solar PV plant opened in Sakaka with a low cost of electricity (amounting to 2.34 US$ cents per kWh) (Alnaser and Alnaser, 2019) and, looking ahead, the world's largest solar-power installation (2060 MW) is scheduled to open in 2025 in Al Shuaibah, near Mecca (Economist Intelligence, 2023). In parallel, there are also some major private initiatives, an innovative practice for Saudi Arabia, which are expected to act as a direct stimulus to other private-sector projects (Alghamdi, 2020): examples include Saudi Aramco's 10.5-MW car park charging system (located on the biggest car park roof in the world of nearly 200,000 m^2), comprising >126,000 PV panels and the King Abdullah Petroleum Studies and Research Center's (KAPSARC) 5-MW solar power plant with 12,000 panels spread over 55,000 m^2.

(1980) originally argued that *situation-specific cognition* directly determines certain behaviours with 'attitude' and 'subjective norms' driving actions (Liu et al., 2020). Building on TRA, Ajzen (1991) developed TPB to explain the links between beliefs and norms, attitudes to intention, and behaviour itself, assuming human behaviour to be rational and choices goal-specific. Conceptualising these relationships, produced a third factor called perceived behavioural control (PBC) (Ajzen, 1991), which refers to people's perceptions about the level of difficulty involved in performing a specific behaviour given their resources, skills, and opportunities (Huijts et al., 2012). Exploiting this scholarship, we investigate the factors that could facilitate or hinder the adoption of RE among Saudi consumers.

We chose TPB as a conceptual framework for three main reasons. First, the concepts (attitude, social norm, and perceived behaviour control) embedded in the theory are well suited to discuss technology adoption. For example, TPB suggests that people with a 'positive attitude' toward 'green products' are more likely to experience social pressure to purchase them. Likewise, those people who believe that the adoption of RE is straightforward are also predisposed to developing the 'intention to adopt RE'. Claudy et al. (2013) considered PBC, attitudes, and subjective norms to be global constructs, and on that basis, together, they proffered a broad concept that has predictive validity when applied over a broad range of behavioural situations. Furthermore, 'social influence' is an important variable to test, particularly since the population of Saudi Arabia largely comprises extended families, tribes, and close-knit communities (Ochsenwald et al., 2022). Additionally, it is important to test PBC as a variable in the Saudi Arabian context because Solar PV is an innovative technology. It is in its infancy (Kiyasseh, 2022). By exploiting TPB, we can focus on consumers' 'intention to adopt' Solar PV as a dependent variable.

Second, previous environmental research demonstrates empirical support for TPB: it has been applied to explain pro-environmental behaviour in several investigations (see for example, Onel and Mukherjee, 2017; Ozaki, 2011). Other studies have probed the adoption of RE systems, energy efficient appliances and other forms of green energy (Albayrak et al., 2013; Greaves et al., 2013; Klöckner, 2013; Wang et al., 2017; Yun and Lee, 2015), as well as recycling, and reduced waste disposal (Mannetti et al., 2004; Onel and Mukherjee, 2017; Ramayah et al., 2012; Romero et al., 2018). It has also been applied to attitude formation and functioning when adopting green products (e.g., Arli et al., 2018; Bamberg, 2003; Kalafatis et al., 1999). Consequently, there is a compelling case for utilising TPB in our work.

Third, TPB is very apposite for conceptualising technological adoption (as established by past work), particularly where the research aims to understand the particular characteristics of user decisions. Helpfully, Mathieson's (1991) study, which discusses the trade-offs between TPB and a technology acceptance model (TAM), suggests that although TPB is challenging to apply, it does provide more specific information that can be especially useful for technology developers. Equally, Cheng (2019) refutes claims that TPB is inferior to TAM in a technology adoption context. For example, in a study concerning the adoption of water saving technology (Lynne et al., 1995), researchers demonstrate strong support for the use of TPB in predicting the likelihood of farmers' willingness to embrace new technological solutions. The use of TPB is as significant and fruitful when researching the adoption of a range of other green innovations (see for example, Borges et al., 2014; Chen and Hung, 2016; Dezdar, 2017; Yang et al., 2022; Hu et al., 2021). This corpus of past research reinforces our decision to adopt the TPB approach.

2.2. Hypotheses development

As indicated above, TPB is a well-established framework that has previously been used to conceptualise empirical environmental problems and issues (see for example, Arli et al., 2018; Bamberg, 2003; Kalafatis et al., 1999; Onel and Mukherjee, 2017; Ozaki, 2011; Yun and Lee, 2015). Our work builds on this past research. We use it to develop six hypotheses as set below.

2.2.1. Antecedents of consumer's intention to adopt RE

2.2.1.1. Attitude toward RE. 'Attitude' is defined as the extent of an individual's favourable or unfavourable assessment of certain kinds of behaviour and plays a vital role in adoption choices (Arli et al., 2018; Claudy et al., 2013). Crucially, previous studies concerning consumer attitudes have researched a range of environmental topics (Hahnel et al., 2014; Qin et al., 2022; Yun and Lee, 2015). For example, studies located in this body of work have highlighted the importance of energy-efficient products (Ha and Janda, 2012), discussed the importance of recycling (Onel and Mukherjee, 2017), reported on the key role of attitude in the adoption of RE technologies (Park and Ohm, 2014), and revealed that attitudes and intention to adopt RE have a positive relationship in the environmental context (Wiser, 2007; Hansla et al., 2008; Paladino and Baggiere, 2008; Batley et al., 2000). Drawing on the above scholarship, we construct our first hypothesis:

Hypothesis 1. Consumers' attitudes toward RE will positively influence intention to adopt RE.

2.2.1.2. Social influence. 'Social influence' is a subjective, norm-based factor that influences individual's beliefs about whether to adopt a particular behaviour, arising out of the approval and/or support (or not) from important groups such as family and friends (Ajzen, 1991; Ozaki, 2011). Ajzen (1991) noted that significant influence stemming from one's particular group or society fosters compliance with their norms to establish or maintain a positive image within the group. Extant research has indicated that reference groups (particularly peers with close proximity to individuals) have a strong influence on their green-related behavioural intentions (see for example, Lee, 2011; Kalafatis et al., 1999; Bollinger and Gillingham, 2012). Crucially, social influence is a particularly significant factor in the Saudi context as communities comprise close-knit extended families and tribes (Ochsenwald et al., 2022) and 'feeling involved' in a social group leads to compliance with its norms (Arli et al., 2018). Given the strong association revealed between social influence and intention to adopt RE, we put forward the following hypothesis:

Hypothesis 2. 'Social influence' has a direct positive influence on intention to adopt RE.

2.2.1.3. Perceived behavioural control (PBC). Perceived behavioural control (PBC) is an integral component of TPB theory and has been extensively employed in academic research, particularly studies concerning purchasing behaviour and intentions (Asif et al., 2023). PBC measures the extent to which individuals have the capacity to engage in a particular behaviour (Klöckner, 2013). It highlights the difficulty of behaving in a certain way (Arli et al., 2018), indicating that the adoption of specific behaviour depends on one's confidence in one's abilities to perform it (Kalafatis et al., 1999). Therefore, PBC is particularly relevant to the scrutiny of the adoption of a new technology when individuals might not feel confident about their capability to operate it (Wang et al., 2016). If individuals have confidence in their skills, resources, and opportunities to adopt (renewable energy) technologies, they are more likely to have a favourable attitude toward embracing them (Klöckner, 2013). Therefore, when individuals perceive a high level of control over their ability to embrace renewable energy technologies, they are more likely to have a positive intention to adopt RE. Drawing on these ideas, we put forward the following hypothesis:

Hypothesis 3. PBC has a direct positive influence on intention to adopt RE.

2.2.2. The elements of the extended theory of planned behaviour

2.2.2.1. Knowledge about RE. Gaining awareness of a product is an initial stage to its subsequent acquisition. It is, therefore, critical to assess how previous product awareness and knowledge affects individuals' purchasing behaviour when studying consumers' decision-making processes. Such prior knowledge can be regarded as customers' prior understanding of the product (Dangelico et al., 2022).

Critically, a lack of information about available technologies is one of the main causes for the slow adoption of renewable energy (Islam and Meade, 2013). People tend to avoid those circumstances where they lack certainty and/or where they feel that they have inadequate knowledge (Asif et al., 2023). Where individuals possess deeper understanding and knowledge, that can result in stronger intentions and subsequent action (Martins Gonçalves and Viegas, 2015). Consumers with better product knowledge are more adept at making purchasing decisions and choosing the option that best fits their purchase criteria than those with less product knowledge (Malik et al., 2020). This may explain why some people do not choose to adopt more sustainable practices, such as recycling, because they feel they have insufficient knowledge (Haron et al., 2005).

As regards green purchase intentions and behaviour, extant research (Arkesteijn and Oerlemans, 2005; Aziz et al., 2017; Pagiaslis and Krontalis, 2014) clearly indicates that the degree of knowledge possessed has a marked effect. Studies have discovered that the more aware consumers are of environmental and social issues, the more favourable their attitude toward eco-friendly products is likely to be, positively impacting their green buying behaviour (Haron et al., 2005). Therefore, where more information is available (i.e. the greater the degree of consumer knowledge), this potentially cultivates consumers' trust in green products and strengthens the 'attitude-intention' relationship. Moreover, whether individuals choose renewable energy (or not) is typically based on their prior experiences. Consequently, it could be argued that those who have previous experience of renewable energy are better placed to evaluate it, and this may strengthen their intention to adopt it. Hence, we formulate the following hypotheses:

Hypothesis 4a. Consumer knowledge about RE has a positive influence on attitude to RE.

Hypothesis 4b. Consumer knowledge about RE has a positive influence on intention to adopt RE.

2.2.2.2. Environmental belief. There is a growing body of literature concerning environmental beliefs (Lin and Syrgabayeva, 2016) and their consequences for consumers' attitudes to RE, environmentally-friendly products, consumers' willingness to pay (more) for RE (Bang et al., 2000; Kilbourne and Pickett, 2008; Lin and Syrgabayeva, 2016), environmentally-friendly consumption (Kilbourne and Pickett, 2008), and the intention to purchase (Pagiaslis and Krontalis, 2014).

Given that TRA suggests that consumers' beliefs control their attitudes, and that evidence of the past results determines their (current or intended future) actions (Ajzen and Fishbein, 1980), it could be argued that consumers' *environmental attitudes* are affected by their beliefs (see Bang et al., 2000; Hartmann and Apaolaza-Ibáñez, 2012; Kilbourne and Pickett, 2008; Nguyen et al., 2017). There is also evidence that a sense of responsibility toward future generations can encourage the adoption of more sustainable energy (Briguglio and Formosa, 2017). In essence, having positive beliefs about the sustainability of RE can result in favourable attitudes toward engaging in environmentally-driven behaviour. Considering these arguments, the following hypotheses are postulated:

Hypothesis 5a. Consumers' environmental belief has a positive effect on attitude toward RE.

Hypothesis 5b. Environmental belief has a direct positive effect on the intention to adopt RE.

2.2.3. Demographic characteristics

We draw on social identity theory (Tajfel and Turner, 2004) and social cognitive theory (Bandura, 1999) to argue for the moderation effects of demographic factors. On the one hand, people strive to achieve a positive social identity by associating themselves with groups that they perceive as favourable. On the other hand, individuals' beliefs, behaviours, and their environment interact to influence their actions. Social Identity Theory suggests that individuals derive a significant part of their self-concept from their membership of various social groups, delineated by characteristics such as gender, age, education, and/or socioeconomic status. Social cognitive theory proposes that behaviour is influenced by personal factors (such as self-efficacy and cognitive processes), environmental factors (such as role models and social norms), and the interaction between them.

Therefore, first, we contend that demographic factors can influence how individuals perceive themselves and others, as well as how they behave in social situations (Domalewska, 2021). Second, individuals' identification with their demographic group can lead to the activation of social norms, and these social identities play a significant role in shaping attitudes and behaviours, which aligns with the theory of planned behaviour. Third, social identity is not only constructed in relationships to social groups; it also defines an individual's relationship with the environment (Gatersleben et al., 2019) and this socialisation process can shape an individual's beliefs about their ability to perform certain tasks or behaviours successfully. Therefore, we can employ the Social Identity Theory and Social Cognitive Theory to provide insights into how demographic factors can moderate the effects of attitudes toward renewable energy by shaping individuals' perceptions, attitudes, and behaviours. Significantly, previous studies have shown that particular consumer segments are more likely to adopt renewable energy. Demographic variables such as gender, age, income, education, and household size have been shown to be important determinants of consumer intention, behaviour, and willingness to purchase green products (see for example, Gerpott and Mahmudova, 2010).

Significantly, the effect of gender on green behaviour is a matter of debate. One line of research suggests that females tend to behave in an environmentally-friendly way when compared to males (Laroche et al., 2001). A second view suggests that males are more likely to engage in environmentally-friendly behaviour than females (Bollino, 2009). A third group of researchers found no significant relationship between gender and willingness to pay for RE (crucially, Zorić and Hrovatin, 2012).

Similarly, there is no scholarly consensus on the effect of age on RE adoption. One view is that age determines environmental attitudes and behaviour (Barber et al., 2014). It has been suggested that older people may behave in 'greener ways' and have a greater willingness to pay for RE (Diamantopoulos et al., 2003; Martins Gonçalves and Viegas, 2015). However, Diaz-Rainey and Ashton (2011) identified a negative correlation between age and attitude toward green energy.

As regards household size, Diamantopoulos et al. (2003) and Rice (2006) find a positive association between family size and the likelihood of environmentally-friendly attitudes. However, household size may not account for variations in willingness to pay for green electricity (Zorić and Hrovatin, 2012). Gerpott and Mahmudova (2010) found a negative association between household size and willingness to pay.

Consumers' levels of income can affect their ability to pay and, therefore, their intention to pay more for more sustainably produced electricity (Diaz-Rainey and Ashton, 2011; Rowlands et al., 2003; Zarnikau, 2003). This also affects their involvement in pro-environmental behaviour (e.g., Arcury, 1990; Tilikidou, 2007). However, some research has not found green purchasing behaviour to be significantly predicted by income (Arkesteijn and Oerlemans, 2005).

Education, meanwhile, has been shown to correlate strongly with the willingness to buy green electricity (Rowlands et al., 2003; Zarnikau,

2003). According to Romero et al. (2018), a positive association exists between educational levels and awareness of environmental issues, suggesting that more highly educated people are better able to understand complex environmental issues.

In summary, several studies have investigated the impact of demographic variables on RE adoption and they have produced conflicting or contrasting findings. The lack of consensus could be explained by cultural differences (Hofstede, 2011) as these studies were conducted in different social contexts.

Drawing on the above concepts and ideas, we formulate further exploratory hypotheses:

Hypothesis 6a. Gender moderates the effect of attitude toward RE on intention to adopt RE.

Hypothesis 6b. Age moderates the effect of attitude toward RE on intention to adopt RE.

Hypothesis 6c. Education moderates the effect of attitude toward RE on intention to adopt RE.

Hypothesis 6d. Income moderates the effect of attitude toward RE on intention to adopt RE.

Hypothesis 6e. Household size moderates the effect of attitude toward RE on intention to adopt RE.

2.3. Intention to adopt RE

Here, it is worth underscoring the point that there is normally a strong association between *intention* and *future behaviour* (Ek, 2005; Fishbein and Ajzen, 1975) where 'intention to adopt' can be defined as an individual preference for making purchases. However, 'intention' does not inevitably lead to *actual* purchases (Aziz et al., 2017; Ozaki, 2011). Indeed, of note for our work, Claudy et al. (2013) identified an *attitude-behaviour gap* in the context of RE. Limited knowledge often prevents positive consumer attitudes toward RE from translating into an intention to purchase (Aziz et al., 2017). Even knowledgeable customers may be deterred by perceived costs and risks (Claudy et al., 2013).

Nevertheless, a positive *intention* toward environmental issues best predicts consumer adoption behaviour because the stronger the intention to purchase, the greater the likelihood of actual adoption (Ajzen, 2001). Overall, *intentions* can exercise a significant positive effect on environmentally-friendly behaviour as shown by some previous important studies (see Arli et al., 2018; Aziz et al., 2017; Martins Gonçalves and Viegas, 2015; Hartmann and Apaolaza-Ibáñez, 2012; Kalafatis et al., 1999; Pagiaslis and Krontalis, 2014; Swaim et al., 2014; Verma et al., 2019; Yun and Lee, 2015).

Accordingly, our research employs consumers' intention to adopt RE as a dependent variable because of the importance of measuring consumers' inclinations in this regard. It is vital to focus on *intention* rather than the actual *behaviour* in the Saudi case because, to date, RE technology is largely absent or, at least, underdeveloped in the country.

2.4. The conceptual model

Drawing on the literature above, we now present our conceptual model (see Fig. 1). Combining TPB and other previous scholarship, in our model 'knowledge about RE', 'social influence', 'PBC', 'environmental belief' and 'attitude toward RE' are considered to be *antecedents* of 'intention to adopt RE'.

The model is designed to assist in evaluating the 'cause and effect' relationship when attempting to assess the intention to adopt RE and in investigating those factors that may facilitate or hinder the adoption of RE among Saudi consumers. Demographic variables such as gender, age, income, education level, household size are tested as *moderators* and scrutinised to determine their impact and direction on the relationship between consumers' attitude toward RE and intention to adopt RE given that past research has produced contradictory findings regarding these issues as reported above.

3. Research methodology

3.1. Sampling procedures

Our research employs a questionnaire survey in order to test the hypotheses set out above. We focus on male and female Saudi consumers, aged 18 years and above, with varying income levels, different educational backgrounds, and contrasting household sizes. Three basic criteria were used to select participants. They were required to be: (i) a Saudi citizen; (ii) the principal decision-maker in their households regarding adoption of RE; and (iii) a home-owner.

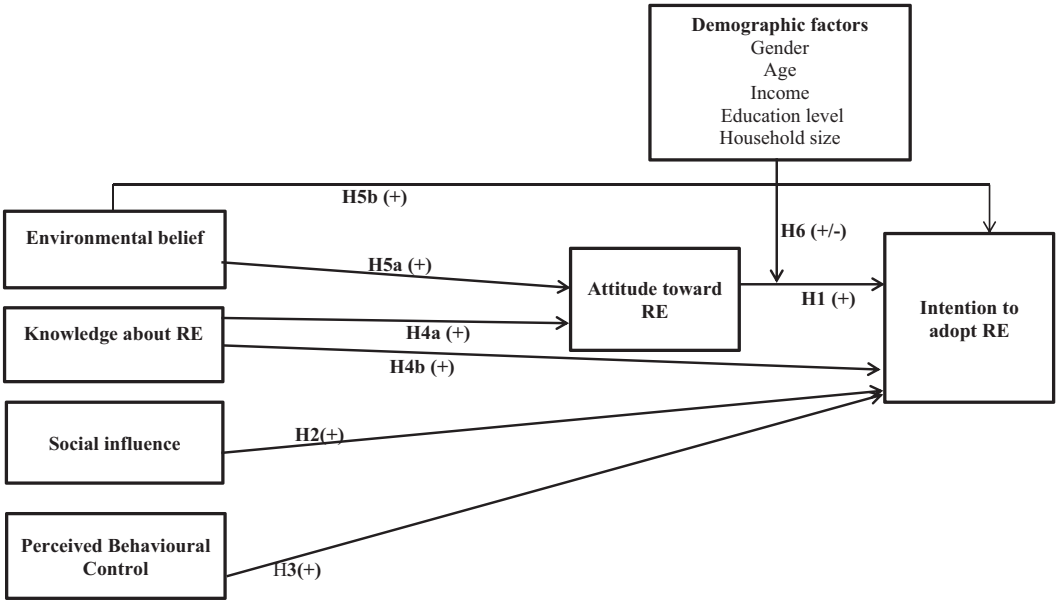

Fig. 1. Conceptual model.

3.2. Instrumental development

The survey items used to test the conceptual model were developed from previously validated measures and reworked to suit our Saudi case. The sources for each of the items was as follows: 'knowledge about RE' was derived from Bang et al. (2000); 'environmental belief' draws on Bang et al. (2000) and Lin and Syrgabayeva (2016); 'attitude toward RE' and 'intention toward RE' was tested by Chan (2001) and Martins Gonçalves and Viegas (2015); 'social influence' stems from Ajzen (1991) and Arli et al. (2018); 'PBC' comes from Bang et al. (2000), Claudy et al. (2011), and Yun and Lee (2015). Note that all except the demographic variables were measured using a seven point Likert scale (1: strongly disagree to 7: strongly agree).

3.3. Questionnaire design

The questionnaire was divided into three sections. (See the appendix for a copy of the questionnaire used). In summary, section 1 of the questionnaire poses questions to ensure participants fulfilled the study criteria (i.e., a Saudi citizen, decision-maker, and homeowner). The second section comprises six elements that operationalise our conceptual model i.e., consumers' knowledge of RE, environmental beliefs, attitudes toward RE, intention to adopt renewable energy, social influence and PBC, and finally, the respondents' demographic profiles.

3.4. Translation and pre-test

The questionnaire was developed in English initially and then translated into Arabic by a translation agency. To ensure linguistic equivalence, a professional translator was employed to translate the questionnaire from English to Arabic and then, later the re-translation into English was validated by another translator.

The questionnaire was piloted with 20 Saudi consumers to verify the comprehensibility of the questions and allow for refinements (Saunders et al., 2016). No significant changes were required following the pilot test study and the final version was produced after some minor changes to the wording.

3.5. Data collection

The data gathering stage of the research employed a self-administrated online questionnaire with respondents being recruited via multiple channels including social media (Facebook, Twitter, LinkedIn), personal emails, groups and apps, the authors' own social network, and further online resources. The data collection phase took place between the start of June and the end of August 2020 producing a total of 450 participants using random sampling.

Prior to data analysis, missing responses checks were conducted. Five questionnaires were removed from the sample of 450: they were incomplete with respondents failing to answer a sufficient number and proportion of the questions in the questionnaire. In accordance with the recommendations of Hair Jr. et al. (2016), those responses where >20 % of data surveys was missing were also removed. Thirty questionnaires were excluded due to failure to meet the inclusion criteria. As a result, a total of 415 questionnaires were valid for further analysis. Potential response bias was checked in accordance with Armstrong and Overton's (1977) method. No statistical differences were found between the answers of early and late respondents. Accordingly, there is a high level of confidence that the data set is unbiased.

3.6. Respondent profiles

Table 1 presents a summary of the profiles of the respondents. In total, 72 % of respondents were male and 28 % female. At this juncture, it is important to note that the 2023 World Economic Forum's Global Gender Gap Report ranks Saudi Arabia among the lowest 10 % countries (130 out of 146) in terms of female economic participation and opportunity (World Economic Forum, 2023). However, it is also vital to underline the point that with rapid modernisation in Saudi Arabia, gender roles are changing. Males and females are increasingly sharing responsibility for household finances (Evason, 2019), although the former still tend to regard themselves as 'protectors' and 'providers' for their families, being the main 'breadwinners' (Evason, 2019). Generally speaking, females still tend to see themselves as mothers and 'homemakers' (Long, 2005). Accordingly, the low rate of female respondents may result from Saudi women lacking sufficient interest in financial issues or the structural practicalities of their houses (such as electricity sources).

Table 1
Profile of respondents.

Categories	Classification	Frequency	Percentage
Gender	Male	299	72 %
	Female	116	28 %
Age	18–34	151	36.3 %
	35–44	77	18.6 %
	45–54	67	16.1 %
	55–64	74	17.8 %
	Over 65	46	11.1 %
Education level	Postgraduate degrees or higher	96	23.1 %
	Bachelor's degree	131	31.6 %
	High school or less	188	45.3 %
Monthly household income	Higher Income	112	27 %
	Middle Income	141	34 %
	Lower Income	162	39 %
Household family size	Small	181	43.6 %
	Large	234	56.4 %

Notes: Higher Income = SAR16,000/$4500 per month or more; Middle Income = SAR10,00015000/$ 2600–4000 per month; Lower Income = SAR3000–9000/$800–2400 or less per month; Small = up to 4 members including children; Large = 5 members or above including children.

In terms of education, 23.1 % of the respondents were qualified to postgraduate level or above, 31.6 % had bachelor degrees. 45.3 % had high school diplomas or less which is consistent with the general Saudi population (OECD, 2019). The majority of respondents were in the 18 to 34 age group (i.e., 36.3 %.) This reflects the result of the average age group of Saudi Arabia (General Authority for Statistics, 2020).

Household income levels were categorised according to the average household income shown by the Saudi Household Income and Expenditure Survey (2018) (General Authority for Statistics, 2019), with those above average being in the higher income bracket. However, those below average were divided into lower and middle income categories in order to examine the moderating effect of income better. Most respondents (39.3 %) had higher incomes while 34 % had a middle-income, and 27 % had low incomes, reflecting the results of the General Authority for Statistics Household's Income Survey (General Authority for Statistics, 2019).

Finally, 'small family' respondents comprised 43.6 % of the total sample and 'large family' respondents accounted for 56.4 %, where the average household size of Saudi Arabia is five members per household (Arcgis, 2021).

Overall, the sample was representative of the national profile.

4. Data analysis

The statistical package for the social sciences (SPSS) and analysis of moment structures (AMOS) were used to analysis the survey data. Before testing the hypotheses, the reliability and validity of the paper's measures were evaluated. To examine construct reliability, we applied Cronbach's alpha analysis to every item and scale. Table 2 shows the range for the Cronbach's alpha values was between 0.76 and 0.96. This exceeds the minimum value of 0.70 indicating that the scale measures are reliable (Hair Jr. et al., 2010). A further assessment of scale

Table 2
Results of the measurement models.

Constructs	Items	Factor loadings	CR	α	AVE	Mean (SD)
Environmental belief	EB1	0.83	0.76	0.76	0.52	6.06 (0.86)
	EB2	0.71				
	EB3	0.61				
Knowledge about RE	KN1	0.93	0.97	0.96	0.90	2.39 (1.61)
	KN2	0.93				
	KN3	0.93				
	KN4	0.93				
Social influence	SI1	0.82	0.88	0.88	0.71	5.46 (1.25)
	SI2	0.86				
	SI3	0.85				
Perceived behavioural control	PBC1	0.89	0.95	0.94	0.83	2.50 (1.44)
	PBC2	0.87				
	PBC3	0.90				
	PBC4	0.89				
Attitude toward RE	ATT1	0.88	0.92	0.88	0.75	6.12 (0.89)
	ATT2	0.88				
	ATT3	0.76				
	ATT4	0.74				
Intention to adopt RE	INT1	0.85	0.81	0.80	0.58	6.06 (0.80)
	INT2	0.78				
	INT3	0.65				

Notes: CR = Composite Reliability; AVE = Average Variance Extracted; SD = Standard Deviation; α = Cronbach's Alpha.

reliability was made by calculating composite reliability (CR). Furthermore, the average variance extracted (AVE) was also calculated for each of the constructs of the conceptual model. The recommended thresholds for each latent construct are that CR should be above of 0.70 and AVE should be above 0.50 (Fornell and Larcker, 1981).

In this paper, the CR values range from 0.76 to 0.97, placing them above the 0.70 threshold, as shown in Table 2. Likewise, the values for AVE were above the 0.50 limit, as they ranged from 0.52 to 0.90, demonstrating internal consistency for the multiple indicators. Construct validity was assessed by calculating convergent validity and discriminant validity. Confirmatory factor analysis (CFA) was applied to evaluate convergent validity, requiring all items within a particular scale to be 0.5 or above (Gerbing and Anderson, 1988). All standardized factor loadings were found to be significant, indicating good convergent validity (see Table 2). Assessment of discriminant validity was made by comparing the squared correlations between constructs and the average variance extracted (AVE) for each. Discriminant validity is indicated if the AVE value is higher than the squared correlations between constructs (Fornell and Larcker, 1981). The variance extracted test for AVE indicated that the AVE for each factor exceeded the square of the correlation coefficient with each of the other factors. In addition, the smallest square root of AVE exceeded the correlation between each construct. This demonstrated good adequacy (Fornell and Larcker, 1981). Table 3 shows that the test confirms the discriminant validity of the model measurement.

To control for the risk of common method bias, several measures were applied, as suggested by Podsakoff et al. (2003), including: careful construction of scale items; counterbalancing question order; and ensuring response anonymity. Harman's single factor test was also conducted (Harman, 1976) to discount common method bias (Podsakoff et al., 2003). The results do not raise any concerns as: (i) the variance accounted by the first factor does not exceed 0.50; (ii) no single factor emerges; and (iii) there are no common factor loadings on the measure.

Table 3
Correlation matrix.

	1	2	3	4	5	6
1. Environmental belief	1.00					
2. Knowledge about RE	0.07	1.00				
3. Social influence	0.24	−0.04	1.00			
4. Perceived behavioural control	0.04	0.60	0.04	1.00		
5. Attitude toward RE	0.47	0.12	0.34	0.07	1.00	
6. Intention to adopt RE	0.34	0.07	0.33	0.16	0.52	1.00

Note: Correlations above 0.12 are significant at $p < 0.05$.

4.1. Structural equation modelling (SEM) analysis

A two-stage analysis SEM was used to analyse the data and test the research hypotheses (Anderson and Gerbing, 1988). Firstly, the measurement model was estimated using CFA, which ensures that the framework constructs are well-founded and validated (Ping Jr, 2004). The literature on psychometrics recommends several indices to evaluate goodness-of-fit (Bagozzi and Yi, 2012; Garver and Mentzer, 1999; Hair Jr. et al., 2010; Kline, 2015). According to the model outputs, the measurement model had a good fit with the data (see Table 2). The goodness-of-fit estimates were Chi-squared (X^2) = 252.135; $p < 0.000$; Degree of freedom (df) = 174; Normed chi-square (X^2/df) = 1.45; normed fit index (NFI) = 0.96; non-normed fit index (NNFI), also known as the Tucker-Lewis index (TLI) = 0.99; comparative fit index (CFI) = 0.99; goodness-of-fit index (GFI) = 0.94; adjusted goodness-of-fit index (AGFI) = 0.93 and Root Mean Square Error of Approximation (RMSEA) = 0.033.

Secondly, the structure of the model was analysed in accordance with the SEM. The theoretical framework was tested using Anderson and Gerbing's (1988) goodness-of-fit indices. The values of the proposed theoretical model exceeded 0.90, as recommended by Bagozzi and Yi (2012), indicating a good fit. All other values exceeded the minimum level $\chi 2 = 496.239$; $p < 0.000$; df = 182; $\chi 2/df = 2.73$; NFI = 0.92; NNFI = 0.94; CFI = 0.95; GFI = 0.91; AGFI = 0.88 and RMSEA = 0.065. These analytical results indicate a good overall data fit for our proposed hypothetical model. Table 4 presents the threshold values indicating good fit.

4.1.1. Goodness-of-fit statistics

$X^2 = 252.135$; $p < 0.000$; df = 174; $X^2/df = 1.45$; NFI = 0.96; NNFI = 0.99; CFI = 0.99; GFI = 0.94; AGFI = 0.93; RMSEA = 0.033. H1, linking attitude toward RE with intention to adopt RE was confirmed ($\beta = 0.06$; $t = 6.26$; $p < 0.001$), as was H2, associating social influence with intention to adopt RE ($\beta = 0.04$; $t = 3.40$; $p < 0.001$) and the relationship (H3) between PBC and intention to adopt RE ($\beta = 0.03$; $t = 4.22$; $p < 0.001$). This concurs with TPB since attitude, social influence and PBC are the main determinants of intention (Ajzen, 1991). There was insufficient evidence to support H4a, that there is a direct positive effect relationship between 'knowledge about RE' and 'attitude toward RE, as the p-value for our results was not significant ($\beta = 0.03$; $t = 1.64$; $p > 0.05$). H4b suggests a positive relationship between knowledge about RE and Intention to adopt RE. Although, statistically significant ($\beta = 0.02$; $t = -1.98$; $p < 0.05$), the results fail to support the stated hypothesis since the t-value was negative (−1.98). H4b was therefore rejected, and the result supports indications of prior research that knowledge acts as a constraint against consumers engaging in renewable energy (e.g., Connell, 2010). H5a associating 'environmental belief' RE with 'attitude toward RE' ($\beta = 0.06$; $t = 9.44$; $p < 0.001$), is supported by the results, as

Table 4
Goodness-of-fit measures.

	Accepted threshold values
Chi-Squared (χ^2)	≥0.05
Comparative Fit Index (CFI)	≥0.90
Goodness-of-Fit Index (GFI)	≥0.90
Normed Chi-Squared (χ^2/df)	≤3.00
Normed Fit Index (NFI)	≥0.90
Non-Normed Fit Index (NNFI)	≥0.90
p-value	≥0.05
Root Mean Square Error of Approximation (RMSEA)	≤0.08

(Sources: Bagozzi and Yi (2012), Garver and Mentzer (1999) and Kline (2015).)

is H5b, linking 'environmental belief' with 'intention to adopt RE' ($\beta = 0.06$; $t = 3.77$; $p < 0.001$). Table 5 shows the standardized path coefficients, as the t-values for each hypothesis.

4.2. The moderation influence of the demographic variables

The effects of the moderators (i.e., gender, age, income, education level and household size) on the association between attitude toward RE and intention to adopt RE were tested using multi-group analysis which allowed a comparison of structural equation models for the different groups. This approach was adopted because the moderator variables are categorical and it also facilitates comparison of the effect of each structural path for different groups (Memon et al., 2019). A median split was used to divide the data for each demographic factor into two groups (male/female, older/younger, etc.) and two separate models were run: a free model, permitting all parameter estimates to vary between the two groups, and a restricted model, using an equality constraint on the moderated link hypothesised for the two groups. Table 6 presents each demographic variable with the significant differences for the path coefficient analysis. A significant chi-square difference (ΔX^2 (1) > 3.84; $p < 0.05$) demonstrates a moderation effect (Leonidou et al., 2013).

Gender had no moderating effect on the link between attitude to RE and intention to adopt (ΔX^2 (1) = 1.662; $p > 0.05$), although male consumers had a greater path coefficient ($\beta = 0.48$; $t = 5.99$; $p < 0.05$) than females ($\beta = 0.28$; $t = 2.65$; $p < 0.01$). Thus, although the moderator effects for gender are insignificant, males showed a more positive moderating effect. Age had a significant moderating effect on the relationship (ΔX^2 (1) = 4.865; $p < 0.05$). The younger group had a more positive effect ($\beta = 0.53$; $t = 5.57$; $p < 0.05$) than the older ($\beta = 0.24$; $t = 3.08$; $p < 0.01$). The moderating effect of household income was positive and similar for all income levels, with no difference for any path (ΔX^2 (1) = 1.350; $p > 0.05$). The moderator effect of educational level varied significantly (ΔX^2 (1) = 7.158; $p < 0.05$), demonstrating greater moderation for more highly educated consumers ($\beta = 0.50$; $t = 7.07$; $p < 0.05$) than for consumers with lower educational level ($\beta = 0.12$; $t = 0.910$; $p > 0.05$). Significantly different effects were found for household size (ΔX^2 (1) = 7.471; $p < 0.05$), with larger families showing a higher moderator effect ($\beta = 0.53$; $t = 6.56$; $p < 0.05$) than small ($\beta = 0.18$; $t = 2.09$; $p < 0.05$).

5. Discussion and implications

Contrary to the results of previous research (Bang et al., 2000; Martins Gonçalves and Viegas, 2015; Pagiaslis and Krontalis, 2014), we find that 'knowledge about RE' has no significant relationship with 'attitude to RE' and is negatively associated with 'intention to adopt RE'. The SEM analysis results show that consumers lacking 'RE knowledge' tend to have a negative intention to adopt RE. Crucially, since Saudi consumers lack knowledge about RE this represents a considerable barrier to adoption of RE in Saudi Arabia.

The discrepancy between our results and those of earlier work may arise because the latter were from studies of Western countries, where consumers are likely to be more knowledgeable about RE (Ramayah et al., 2010). When Saudi consumers were questioned about their level of knowledge and familiarity with RE, the results indicate that it was generally low. In Saudi Arabia, oil has traditionally been very inexpensive and used as an energy source (Hasanov and Shannak, 2020). Consequently, Saudi consumers have been less motivated to engage with RE information, despite the global growth in awareness of RE and climate change (Dincer and Rosen, 1998) and its adverse consequences associated with greenhouse gas emissions (Fitch-Roy and Fairbrass, 2018). The lack of knowledge among respondents may also reflect Lin and Syrgabayeva's (2016) assessment that few citizens of developing countries appreciate the benefits of green energy. Nevertheless, Saudi consumers' awareness of RE may evolve and so too their intention to adopt it, while poor knowledge will almost certainly hinder acceptance.

Our findings suggest that consumers' 'environmental beliefs' impact positively on both their 'attitude to RE' and their 'intention to adopt' the technology. These findings are consistent with previous studies (Bang et al., 2000; Kalafatis et al., 1999; Pagiaslis and Krontalis, 2014). Our hypotheses are supported, and our data reveals that 'environmental beliefs' have a more pronounced impact on 'attitude' than on 'intention to adopt', suggesting that consumer beliefs may not directly result in intention to adopt RE despite the close association with a favourable attitude. This, again, may reflect limited knowledge of RE among Saudi consumers (Düştegör et al., 2018) as indicated by our research and may influence the strength of consumer's intention to adopt RE.

Our results indicate that 'attitude to RE' directly influences consumers' 'intention to adopt RE'. 'Attitude' is an important predisposition (Verma et al., 2019). Consumer attitudes and behaviour are often consistent (Gupta and Ogden, 2009). Our results indicate that Saudi consumers do have a favourable attitude to RE, which concurs with earlier studies (Arli et al., 2018; Bang et al., 2000; Verma et al., 2019) and with TPB, where 'attitude' is highlighted as the main determinant of 'intention' (Ajzen, 1991). However, while a positive attitude to RE is the strongest predictor of adoption by Saudi consumers, a lack of knowledge creates a significant hurdle.

Our research also furnishes empirical evidence concerning the significant effect of 'social influence' on intention to adopt RE, as previously documented (Lee, 2011; Ozaki, 2011). Social influence could increase RE adoption in Saudi Arabia as individuals act in accordance with group norms to signal 'belonging' (Arli et al., 2018) and peer influence can change beliefs and actions (Aziz et al., 2017). The power of social influence is highly significant in Saudi Arabia owing to the country's structure of close-knit extended families, tribes, and communities (Ochsenwald et al., 2022). Thus, social influence is an essential aspect of encouraging consumer adoption of RE. Crucially, Saudi Arabia has the strongest Islamic culture of the Arab countries and strong environmental belief is an element of Islam (Al Lily, 2011), which affects consumers' environmental beliefs and attitudes (Rice, 2006). Religious beliefs and cultural norms are inextricably linked in the country.

Analysing the TPB variables indicates that PBC is the second most positive antecedent of intention to adopt RE. This finding is consistent with previous environmental studies as PBC influences intention in various 'green' contexts (Arli et al., 2018; Onel and Mukherjee, 2017; Yun and Lee, 2015). To assess PBC, participants were asked about their knowledge of RE system costs, operation, installation, and maintenance requirements because a lower PCB leads to a lower intention to adopt (Düştegör et al., 2018). Nevertheless, our results indicate a close link between PBC and intention to adopt RE. This apparently contradictory finding may arise from the novelty of the technology, leading to a lack of knowledge about costs. Uninformed or misinformed consumers might mistakenly believe that RE can produce all requisite electricity and eliminate fuel bills. This may explain the lack of statistical difference in moderation by income level: without rudimentary knowledge about RE,

Table 5
Results of the structural model.

	Independent variables	Dependent variables	Estimate (T-value)
H1	Attitude toward RE	Intention to adopt RE	0.06 (6.26) ***
H2	Social influence	Intention to adopt RE	0.04 (3.40) ***
H3	Perceived behavioural control	Intention to adopt RE	0.03 (4.22) ***
H4a	Knowledge about RE	Attitude toward RE	0.03 (1.64)
H4b	Knowledge about RE	Intention to adopt RE	0.02 (−1.98) *
H5a	Environmental belief	Attitude toward RE	0.06 (9.44) ***
H5b	Environmental belief	Intention to adopt RE	0.06 (3.77) ***

Notes: (1) * $p < 0.05$ ** $p < 0.01$. *** $p < 0.001$. (2) Chi-squared (X^2) = 496.239, $p < 0.000$; df = 182; Normed chi-square (X^2/df) = 2.73; Normed Fit Index (NFI) = 0.92; Non-Normed Fit Index (NNFI) = 0.94; Comparative Fit Index (CFI) = 0.95; Goodness-of-fit Index (GFI) = 0.91; Adjusted Goodness-of-Fit Index (AGFI) = 0.88; Root Mean Square Error of Approximation (RMSEA) = 0.065.

Table 6
Results of moderation analysis.

	Moderators										
	Gender		Age		Education		Household income			Household size	
Path	Female ($N = 116$)	Male ($N = 299$)	Young ($N = 151$)	Old ($N = 264$)	Low ($N = 188$)	High ($N = 227$)	Low ($N = 112$)	Middle ($N = 141$)	High ($N = 162$)	Small ($N = 181$)	Large ($N = 234$)
ATRE → ITARE	0.28 (2.65) **	0.46 (5.99) **	0.53 (5.57) **	0.24 (3.08) **	0.12 (0.91)	0.50 (7.07) **	0.34 (3.62) **	0.57 (3.18) **	0.34 (3.81) **	0.18 (2.09)*	0.53 (6.56) **
Δ X^2	1.66		4.86*		7.16**		1.35			7.47**	

Notes: (1) * $p < 0.05$ ** $p < 0.01$. (2) ATRE = Attitude toward RE, ITARE = Intention to adopt RE.

consumers may be ignorant of the costs involved.

5.1. Moderating effects of demographic variables

Our findings show that gender has a more marked moderation effect on the relationship between 'attitude to RE' and 'intention to adopt' among Saudi consumers. This contrasts with previous research that indicates females are more environmentally aware (Jansson et al., 2011; Laroche et al., 2001). This is particularly surprising when compared to Diamantopoulos et al. (2003) whose study that found that females were more concerned about environmental matters and would act accordingly. Arguably, our findings reflect the fast-changing nature of gender roles in Saudi society, with women more frequently sharing financial responsibilities, while cultural norms still see men as 'protectors' and 'breadwinners' (Evason, 2019), influencing gender differences in RE adoption intention.

Our results indicate that age has an important moderating impact. Younger consumers are more likely to adopt RE than older individuals given their direct experience of environmentally aware lifestyles with many younger Saudi citizens having studied overseas. For example, in 2018, 90,000 Saudi students received government scholarships (Arab News, 2019), allowing them to travel and study abroad, exposing them to different national customs and environmental behaviour, potentially increasing their likelihood of adopting RE (Alqahtani, 2014).

Higher educational attainment levels have a more significant positive moderating effect, which supports earlier research (Diamantopoulos et al., 2003; Sommerfeld et al., 2017; Zorić and Hrovatin, 2012). Higher educational levels tend to create more environmental awareness (Mosly and Makki, 2018) and influence attitudes to new technologies (Binyamin et al., 2019). Possessing a degree makes individuals 25 % more likely to behave in environment-friendly ways (ESRC, 2011), perhaps reflecting a greater appreciation of RE and long-term global climate issues. According to Jansson et al. (2011), higher educational levels increase learning capacity and foster more open attitudes.

In contrast to the expectation of having higher levels of adoption with higher income, the positive moderating effect was fairly consistent across the three income levels groups. Rowlands et al. (2003) posit that a higher income raises consumers' intention to buy RE, making products and services more affordable. Some researchers regard income level as an essential aspect of consumers' intention to adopt RE (Diaz-Rainey and Ashton, 2008; Rowlands et al., 2003), biofuels (Pagiaslis and Krontalis, 2014), and other green behaviour (Streimikiene and Baležentis, 2015; Zorić and Hrovatin, 2012). The surprisingly positive moderation with the low- and middle-income groups (at the same level as the high-income group), may suggest that consumers believe that the Saudi government will subsidise RE installation as part of the *Vision 2030* programme given that domestic electricity already attracts subsidies (Hasanov and Shannak, 2020; Sarrakh et al., 2020). In parallel, the Saudi government treats energy subsidies as an essential element of its macroeconomic policy (El-Katiri and Fattouh, 2017). Consumers in middle- and lower-income brackets might, therefore, assume they will receive government subsidies for RE.

Having a large family group has a greater positive moderating effect than having a small family, which corresponds with earlier research (Bollinger and Gillingham, 2012; Diamantopoulos et al., 2003; Jansson et al., 2011). This could be explained by the greater electricity costs that a larger family face when compared to a smaller one. Typically, a larger family will require a bigger house that will result in higher electricity costs. This is true for the extensive use of air conditioning during the hot Saudi summers.[6] A large Saudi family may therefore benefit financially from adopting RE to reduce their energy costs.

5.2. Policy implications

Our research results potentially have significant implications for the Saudi government and other policymakers. First, it shows that in the effort to combat climate change and environmental damage, governments ought to focus on new technology adoption in the same way they have on finding the correct technological solutions. Second, Saudi consumers currently lack knowledge about RE and/or the motivation to adopt RES, a technology which is still in its infancy in the country. Consumer knowledge about new technology, which is essential for adoption, derives from their social networks (Ozaki, 2011). Therefore, it is important for policymakers to concentrate on developing knowledge about RE among Saudi consumers as a means of cultivating adoption. Crucially, while belief in environmental protection may be strong, it is not enough to persuade people to adopt RE. Critically, educational campaigns about the advantages of adopting RE could improve knowledge among Saudi consumers and encourage RE adoption. Social media could play a key role to play in disseminating information given that Saudi Arabia is a global leader in social media activity[7] (Global Media Insight, 2021). Arguably, initially, it would be best to provide basic information about RE since there is currently little available in Saudi Arabia. A paucity of simple but clear information about environment-friendly products has been noted as being problematic for consumers (Ha and Janda, 2012). Moreover, too much emphasis on the technical aspects (at the first stage of adoption) could result in an overall lack of understanding.

Thirdly, our research emphasises the need to pay special attention to the ways in which peer groups can influence consumers' intentions and leads to a consideration about which Saudi social norms can be used to encourage adoption among Saudi consumers. For example, Saudi families usually hold a weekend meeting at home with their relatives (both close and distant), an event labelled a 'majalis'. Gatherings of this kind can be very large and one extended family may include an entire neighbourhood (Evason, 2019). The 'majalis' is a forum for discussion of news and recent event, a place where opinions are formed (Long, 2005) and where family leaders can act as 'influencers'. These events could be used to help increase the adoption of RE.

[6] According to Enerdata (2019) Saudi Arabia has the world's highest share of air conditioning in household electricity. - Enerdata. Future of Air-Conditioning; Enerdata: Grenoble, France, 2019.

[7] It is estimated that 25 million active social media users in Saudi Arabia spend an average of 3 h a day using it (Global Media Insight, 2021).

Finally, demography should be taken into consideration. It is important to target males to improve their knowledge about RE, since Saudi males still tend to be the main decision-makers within the household. In addition, policymakers should focus on young consumers, who are those most likely to be needed to bring to fruition the Saudi *Vision 2030*. Although RE adoption promotion could be useful among well-educated consumers, the major concern for policymakers is the need for educational programmes for non-educated or less well-educated consumers. Educational institutions have a vital role to play bearing in mind that a key impediment to adoption is a lack of focused educational programmes to promote RE among consumers (Rundle-Thiele et al., 2008).

6. Conclusions and future directions

Our research empirically investigates factors which may encourage or hinder RE adoption among Saudi consumers, which is vital in the light of Saudi government plans to produce 50 % electricity generation from renewables by 2030 (Lo, 2021). The core finding of our study is that a lack of knowledge about RE among Saudi consumers is significant barrier to the adoption of RE and this obstacle may thwart the Saudi government's endeavours to encourage domestic RE adoption. Additionally, our findings demonstrate that while Saudi consumers' environmental belief does not necessarily lead to the intention to adopt RE, it is significantly associated with positive attitudes toward RE.

Crucially, our findings suggest favourable attitudes to RE exist among Saudi consumers. Social influence has been demonstrated to be a vital tool encouraging RE adoption. Gender, age, and family size are highlighted as having a significant and positive moderating influence between attitudes to RE and intention to adopt RE. Younger consumers were more likely to have an intention to adopt RE, as were members of larger family households, possibly reflecting the financial benefits of lower bills or a religious belief in environmental responsibility. Remarkably, being in a high-income bracket had no significant moderating influence between attitude and intention to adopt RE, possibly due to ignorance about costs or because consumers expect to receive government subsidies. The study recommends that the Saudi government and policymakers should concentrate mainly on developing consumer knowledge about RE to encourage RE adoption.

The limitations of this study present possibilities for future research. Firstly, it is difficult to generalize the current findings beyond Saudi Arabia because of its cultural distinctiveness. However, given that our research is exploratory, it does offer a springboard for future studies of similar cultures such as those found in countries such as the United Arab Emirates or Kuwait. In the longer term, the research model that we employ could be utilised in investigating a range of other Gulf Cooperation Council (GCC) counties. Secondly, RE consumer research has long concentrated on Western cultures with minimal attention paid to non-Western contexts such as China and Malaysia (but see for example: Irfan et al., 2021; Aklin et al., 2018a; Aklin et al., 2018b). From a theoretical perspective, cross-cultural research is required to provide comparisons about consumer perceptions and to understand the catalysts for and obstacles against RE adoption in the light of cultural differences, environmental understanding, and social and cultural norms (Ozaki, 2011). Thirdly, our study measures only consumers' intention to adopt RE in Saudi Arabia (since RE technology is not likely to be fully implemented until 2030 at the earliest). However, the transition from *behavioural intention* to *actual behaviour* requires further investigation (Ng et al., 2018). Such research could strengthen our understanding of the association between intention and behaviour. Fourthly, the research reported here is confined a quantitative study but by extending the work to include qualitative research (e.g., obtained from in-depth interviews with consumers) we could deepen the research. Finally, the planned face-to-face survey methods, proposed for use alongside the online survey, proved to be impractical owing to the Covid-19 pandemic, thus excluding non-computer users. Therefore, future research should widen the base of participants by using face-to-face surveys. In summary, while our research makes a major contribution both empirically and conceptually, there is scope for further future international comparative research concerning consumers and their attitudes and behaviour regarding RE generally and Solar PV in particular.

CRediT authorship contribution statement

Abdulkarim Alsulami: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – original draft, Writing – review & editing. **Jenny Fairbrass:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. **Tiago Botelho:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. **Shahin Assadinia:** Formal analysis, Methodology, Writing – review & editing.

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.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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