The purpose of this research study is to reveal the current status of and the willingness to adopt renewable energy technologies in the western region of Saudi Arabia. The main contribution of this work is the revealed levels of background knowledge presented on six types of renewable technologies, as well as five willingness perspectives on adoption by different sociodemographics. This was achieved following a quantitative research study to randomly collect cross-sectional data from 416 participants using a carefully designed questionnaire survey. Descriptive and inferential statistics were used to analyze the collected data. Results of the study provided and ranked the background knowledge of participants’ viewpoints on six renewable energy sources. It was revealed that education is paramount in increasing the level of awareness of renewable energy technologies. The results also ranked the five willingness perspectives to adopting renewable energy technologies. It was revealed that the economic factor is the main factor influencing the willingness to adoption. The analysis also showed that age was an important factor influencing the adoption of these technologies. This research study acts as a guide assisting energy policy-makers, government agencies, and investors in designing better-targeted public awareness and marketing campaigns on renewable energy technologies. This is in turn will assist in achieving the energy efficiency and production targets of Vision 2030 in Saudi Arabia.

Keywords: renewable energy technologies; willingness; adoption; public perception; Saudi Arabia

1. Introduction

Environmental pollution, greenhouse gas emissions, and climate change have been recently amongst the worldwide most significant global environmental concerns [1]. Continuously increasing levels of carbon dioxide (CO$_2$) and other greenhouse gases in the atmosphere are threatening the environment [1]. The trends in CO$_2$ emissions are highly dependent on energy production and consumption levels, energy intensity, the cost of energy and its accessibility [1]. Both industrial development and economic growth are derived from energy [1]. The consumption of energy is vital to the wellbeing of humans as well as to economic activities [2]. An economic and social growth constraint in several parts of the world is the lack of access to contemporary energy that is reliable and affordable [2]. It is assumed that a nation with large energy consumption will also have a high living standard [1]. Consequently, this high-energy consumption will produce high amounts of CO$_2$, leading to the harmful effect on the environment [1].

Saudi Arabia is one of several countries that has an abundant supply of fossil fuel resources [2]. Its wealth in these resources has led to overuse of energy and the high production of CO$_2$ emissions [2]. In 2012, Saudi Arabia was the world’s leading oil producer and the second largest holder of crude
oil reserves [2]. Energy is heavily subsidized in Saudi Arabia, resulting in overuse and inappropriate allocation of oil and natural gas resources [2]. Furthermore, the gross domestic product (GDP) of Saudi Arabia is mainly dependent on energy exports [2]. Reducing CO₂ emissions in Saudi Arabia is necessary due to the country being one of the largest polluters on the planet [2]. It is forecasted that if the domestic oil consumption continues to increase at the current rate, by the late 2030s the kingdom will consume all of its oil production [3]. The Saudi government can adopt an energy conservation strategy through energy price changes and fuel replacement [1]. As energy prices increase, both users and producers will reduce the energy consumption, and as a result energy efficient technology would be adopted, resulting in CO₂ emissions reduction [1]. Investing in renewable energy sources such as solar and wind powers, to control the use of fossil fuel and CO₂ emissions is an urgent matter [2].

Currently, there are no specific regulation or policies on renewable energy technologies (RETs) usage in Saudi Arabia, but the government has set an ambitious strategy plan to adopt RETs on a wide scale. The kingdom is introducing several initiatives, including increasing investments in downstream assets, gas, renewables in the power sector, as well as increasing energy prices for domestic use and enhancing efficiency [4]. The Vision 2030 targets for Saudi Arabia contain an obligation to renewables for 9.5 GW by 2030 [4,5]. Vision 2030 classifies renewable energy as one of the pillars for broadening economic status so that it is more than just oil [3]. It also seeks to localize several significant aspects in the Saudi economy, such as research and development, manufacturing, and other design and distribution stages [5]. The Vision 2030 also stresses localization of the manufacturing of renewable energy and industrial equipment sectors in Saudi Arabia [3,5,6]. The current legal and regulatory framework will be reviewed to allow private sector engagement in renewable energy, including purchasing and investment activities [5]. As part of the Vision 2030, the government also launched a smaller scale program called the National Transformation Program 2020. This program was announced after the Vision 2030 with a renewable target of 3.45 GW by 2020, which represents 4% of the total power consumption of the kingdom [3].

To endorse clean energy, it becomes necessary to find the correct balance between economic, social, and environmental factors due to the typically higher cost of these technologies compared to traditional ones [7]. It is possible to measure the preference of consumers on several RETs through the use of a very useful tool by measuring their willingness to pay [7]. The public opinion on RETs must be acknowledged by decision-makers as it represents a significant variable for policy-makers and investors [8]. Ignoring this social variable can lead to limiting the wanted development of RETs [8].

The research herein was conducted to better understand the public perception in Saudi Arabia of RETs, and their willingness to adopt these technologies. The driver of this research was the lack of information on public perception of RETs in Saudi Arabia. The research problem is to collect information on: how the public rates and ranks its level of background knowledge on RET sources; and what are their willingness perspectives to adopt RET sources and how they rank them; what are the significant sociodemographic determinants of background knowledge on RET sources; and what are the significant sociodemographic determinants of willingness perspectives to adopt RET sources. Such information is very significant to many renewable energy stakeholders, such as RETs suppliers, installation contractors, operation and maintenance companies, the government, etc. New energy technologies typically receive disapproval from the public [9]. This research will serve as a guide for RETs stakeholders on the status and public willingness to adopt RETs. The following sections will include a literature review, research methodology, results and discussion, and a conclusion.

2. Literature Review

2.1. Renewable Energy Technologies

The demand for RETs is growing worldwide. These technologies depend on renewable energy sources to produce energy. Natural sources are the supply of renewable energy and can be used continuously [10]. This includes solar, wind, geothermal, hydro, biomass, and wave energy. The following sections will discuss the aforementioned types of renewable energies.
2.1.1. Solar Energy

Worldwide, solar energy technologies have become well established and widespread [11]. Saudi Arabia has become the largest market for photovoltaic (PV) projects within the six Gulf Cooperation Council countries and is expected to be leading the region in acting as a hub for solar energy development [12]. Solar energy can be incorporated using many different systems, which will help society to overcome its dependency on conventional fuels [13]. It is considered a cheap, abundant, and endless source of renewable energy [13]. This energy source can offer energy security and independence, due to its continues supply [11]. Furthermore, it is non-polluting, clean, and consistent [11]. Recently, an increased enhancement in the efficiency of solar power technologies was achieved along with a reduction in its costs, which is forecasted to continue [11]. Several European countries such as Germany have developed special regularity mechanisms to promote the use of PV technologies through government programs and incentives [14]. The main issue with solar powered systems is its high capital costs [10,15]. Fortunately, as energy prices increase internationally, the cost of solar energy is declining [15]. The cost of PV energy declined 50% between the years 2010 and 2014 [16].

2.1.2. Wind Energy

Wind power will play a significant role in attaining a post-fossil carbon society [17]. Deployment of renewable energy resources such as wind is a practical solution towards an environment that is clean, sustainable, and secure [18]. Wind energy is rapidly growing worldwide [18–20]. It will continue to grow due to being abundant, domestic, inexhaustible, and clean [20]. Wind energy does not use fossil fuel, and thus does not pollute the air [21]. It was the first to be realized on a commercial scale among other new technologies [20]. The extraction of wind power using contemporary turbines is now globally well-established [22]. Forecasting a representative way to harvest onshore and offshore wind will be significant in planning the technology systems to be used, knowing the investment needs, and designing the correct policies [23]. It is essential to be knowledgeable on wind behavior in order to evaluate the performance of wind turbines [22]. Wind speed and frequency are very dependent on location, and this explains why wind farms are only located in specific regions in the world [22]. The turbines are classified as either large wind turbines (LWTs) or small wind turbines (SWTs) [18]. There are also two categories of wind turbine: horizontal axis or vertical axis wind turbines, with horizontal axis wind turbines being the most commonly used [21]. Wind turbines are installed onshore or offshore depending on the locations with adequate wind resources [21]. Offshore locations are more attractive, due to higher wind speeds, extra reliability, and consistency [21].

2.1.3. Geothermal Energy

Geothermal energy is an environmentally-friendly source of renewable energy [24,25]. It is a sustainable source that can generate electricity, heating/cooling, and can be applied in other industrial applications [26]. Compared to other existing energy generation technologies, it has the lowest environmental impact, due to its marginal resource requirements for construction and maintenance [25]. Geothermal energy is a sustainable resource that can provide societies with access to a carbon-free future [27]. Geothermal technologies emit very minor levels of carbon dioxide [27]. The only emissions that exist arise from the underground reservoir fluids [27]. Growth of geothermal adoption is slow compared to solar and wind technologies [27]. Projections indicate that energy use will increase worldwide, and geothermal energy use will also increase considerably for both electricity generation and heating [28]. The potential of geothermal energy does not exist in all countries, but those that lie on the ring of fire have access to geothermal energy resources [29]. In several southern countries, geothermal energy plays a major role [30]. Out of the top 15 countries that use geothermal technology for electricity production, 10 countries are developing countries that include the Philippines, Kenya, Indonesia, Mexico, and several Central American states [30]. The geothermal heat pump is derived
from geothermal energy and is considered an efficient application [24]. It uses the Earth as a source of heat and extracts it to heat spaces in winter [24]. Conversely, it uses the Earth as a heat sink by transporting heat from the space to earth, and thus cooling the space during the summer session [24].

2.1.4. Hydro Energy

Hydropower generation technology is considered clean, efficient, and trouble-free [31]. Globally, it plays a significant role in electricity generation and is currently the largest renewable source in the world [32]. It is also one of the cheapest and readily available energy sources [33]. When compared to other renewable technologies, it has a typically small social and environmental impact [31]. Because hydropower technology is both flexible and reliable in integrating and developing energy systems, it is amongst the oldest techniques and consists of small to large-sized systems [32,33]. Impulse momentum is the basic principle governing hydropower technology [31]. It consists of two main steps: firstly, the potential energy of the water is converted into mechanical energy; and secondly, the mechanical energy is transformed into electrical energy [31]. The rotation of the turbines achieves the first step and generators achieve the second step [31]. However, hydropower generation technology also faces several vital social and environmental hindrances and restrictions that obstruct its development [15]. Hydropower generation technology is already being exploited in many developed countries [15].

2.1.5. Biomass Energy

Biomass energy is a renewable source that consists of carbon, nitrogen, hydrogen, and oxygen [34]. The name biomass is given to the substance as a result of the photosynthesis process, where the energy from the sun converts water and carbon dioxide into an organic substance [35]. It encompasses biological waste (i.e., domestic, forest or organic waste), agricultural production by-products, and agro-industrial or food industry waste [34,35]. Furthermore, it is one of the earliest sources of energy for human beings [35]. Many applications exist for biomass energy including electricity generation, heating, and vehicle fuel [35]. Biomass energy can assist with the issues of global warming and climate change, as well as providing energy reliance and safety [36]. Biomass energy gets to the heart of sustainable development, due to its strong links to food security and the environment, which is a point that is disregarded by policy makers when favoring contemporary energy [37]. The promotion of biomass energy generation in several developed and developing countries is made through regulated policies and financial incentives [34]. In developing countries, biomass energy is used mainly for cooking and heating, and in industrialized countries it is used mainly for heating, combined heat, and power (CHP), and biofuels [38]. When compared to fossil fuel, biomass fuel has a moderately cleaner combustion [39]. Transportation fuels such as biodiesel and bioethanol, or biogas such as biomethane can be produced from biomass [40]. It is forecasted that the importance of biomass energy will increase with forestry, agriculture, and organic waste being the essential base of the biomass energy option [15].

2.1.6. Wave Energy

Wave energy is the most abundant source of energy in the world [41]. It is an unconventional renewable energy source that is interesting because of its high density and presence worldwide [42]. The energy density is considered to be the highest amongst all renewable sources [43]. The last few decades have seen a significant increase in wave energy due to the need to decrease greenhouse gas emissions [44]. It is expected that wave energy will also play a large role in the future of energy supply systems, even though presently none of the wave energy convertors have been commercialized [44]. Wave energy depends on the motion of the waves and harnesses kinetic and potential energy [45]. The wave characteristics such as the wave height, period, location, and seasonal variation all affect the total amount of energy generated [45]. One of the great challenges for energy engineers and scientists is the harvesting of wave energy, and many methods have been attempted [46]. It was found that it was very difficult to adopt most of the wave energy methods in a real ocean environment, due to
the technological and economic complexity [46]. Wave energy harvesting methods still lack maturity overall [45]. It might still take decades to obtain significant energy generation from wave energy systems [15].

2.2. Willingness to Pay and Invest in Renewable Energy Technologies Worldwide

A significant requirement to the successful adoption of any technology is social acceptance, which may be often overlooked [47]. With regard to the perception and public acceptance of new expanding forms of energy, limited number of works exist in the theoretical and empirical literature [47]. Investors and decision-makers are faced with extra challenges, because of the increasing significance of renewable energy systems on electricity generation [48]. Private investors believe that it is fundamental to guarantee public acceptance in order to reduce the risk of cost overruns, failure, or cancellation [48]. Public acceptance differs with the technology type and is associated with the local financial reimbursement regulations, as well as other fundamentals, such as job creation or local development [48]. Several European governments are progressively using public resources to enable the switch from fossil fuel energy systems to sustainable energy systems [49]. The unwillingness of the public to adopt renewable energy and resistance to the construction of renewable energy facilities remain key barriers to the evolution of renewable energy in a number of European and North American countries, including the United Kingdom [50]. Citizens that oppose renewable energy are referred to as NIMNYs (Not In My Back Yards) [50].

A study in Portugal has investigated the significance of RETs for electricity generation and has examined the social acceptance of hydro, wind, biomass, and solar RETs along with identifying the major concerns [48]. The study results show that there is a positive outlook toward RETs in Portugal with the public being well aware of these systems [48]. Nevertheless, the public’s knowledge on capital cost, electricity bill effect, and feed-in-tariffs availability was low [48]. A study took place in Lithuania to investigate the public’s willingness to pay for a number of renewable energy technologies [7]. It revealed that house owners are interested and are ready to pay extra for solar energy-based technologies over biomass and wind [7]. In another study that took place in Yemen, the public’s knowledge, attitudes, and behavioral intention to do with the use of several renewable energy sources, especially solar energy, was studied [51]. These data were then used to determine the basis for setting policies that motivate the use of renewable energy [51]. An evaluation of the public willingness to pay extra, to change their current source of electricity, and to invest in feed-in-tariffs were a portion of the study [51]. The results showed that 76% of people living in an urban area and 60.1% of people living in a rural area knew about renewable energy sources [51]. Solar and wind renewable energy sources were the most well-known and geothermal energy source was the least known [51]. Generally, the public of Yemen showed a constructive attitude toward the use of renewable energy, specifically solar energy [51]. Furthermore, the public was willing to pay extra and to invest in feed-in-tariffs, with a moderate willingness to change their current source of electricity [51].

The public perception and willingness to pay was studied in Greece and revealed similar results to other European countries such as Spain and Slovenia [52]. Study participant showed a positive attitude toward RETs and willingness to pay was directly linked to education, subsidies and government support [52]. Another study that targeted the western part of Greece found that the willingness to pay for renewable energy projects is linked to income and environmental organization memberships as well as the renewable energy potential [53]. In Crete, a study was completed to analyze and evaluate the public acceptance and willingness to pay for renewable energy sources [54]. The study revealed that most of the public was very progressive toward the implementation of renewable energy sources [54]. Social acceptance of wind energy was investigated in China [17]. There was a general level of support for wind energy, but it was largely reduced when citizens were asked to install wind turbines on their properties or when asked to pay for higher electricity prices [17]. Thus, it is significant to highlight that the acceptance of renewable energies does not indicate the willingness to pay for them [17]. The study also showed that factors such as age, income, education level, and property location had an effect
on the social acceptance of wind energy [17]. In Hong Kong, the public willingness to pay for green housing attributes (including RETs) was explored [55]. It was concluded that the willingness to pay was derived mainly by economic incentives [55]. The willingness to pay for sustainable buildings (includes RETs) by office building tenants was investigated in Singapore [56]. The study showed that older tenants have a lower willingness to pay for sustainable features, and that the demand for sustainable buildings is for improving the image of the organization [56].

3. Methodology

To achieve the main objective of this research study, a quantitative research design was followed using a random sampling process to collect cross-sectional data using a mixed mode survey. Both printed paper and online questionnaire survey versions, which were created via Google Forms, were used in this study. This is to ensure independency of data (i.e., every response comes from a different person), and targeting higher data coverage of hard-to-reach sociodemographic groups of respondents. Both paper and online surveys were randomly circulated using different online channels (i.e., Gmail, WhatsApp, LinkedIn, and Twitter). The online questionnaire survey was designed to collect detailed data pertaining to the respondents’ sociodemographic characteristics, background knowledge on RETs, and willingness to adopt RETs. The option of limiting the response to one for each respondent was used on the Google Form settings menu. This option assist in stopping the repeated completion of questionnaire survey by the same respondent.

The sociodemographic characteristics of respondents included: gender, nationality, age, educational level, income level, employment status, marital status, accommodation type, and accommodation ownership status. The depth of background knowledge on six RETs (i.e., solar, wind, sea wave, hydroelectric, geothermal, and biomass) was also collected. Moreover, data on the willingness to adopt RETs was collected. This was accomplished by collecting data on five willingness perspectives (i.e., willingness to save the environment, willingness to change from traditional energy sources to RETs, willingness to pay more for using RETs, willingness to own RETs, and willingness to invest in RETs infrastructure).

Respondents were asked to rate their background knowledge on a scale of two (i.e., I have, or, I do not have a background knowledge) for each of the six RETs. The willingness to adopt RETs was measured on a scale of three (i.e., willing, neutral, or unwilling) for each of the five perspectives mentioned above.

The used data in this research study was restricted to the residential sector public in the western region (i.e., Jeddah, Rabigh), Kingdom of Saudi Arabia (KSA). All data were collected in the first and second quarters of 2017 from 416 respondents, 251 (60.33%) and 165 (39.67%) responses were collected from paper and online questionnaire surveys, respectively.

The sufficiency of the sample size was ensured using the G*Power 3.0.10 software [57,58]. It was used to calculate the statistical power and effect size for the chosen statistical method in this study (i.e., Pearson’s chi-square test). Typically, a sample size is selected such that a probability level of 0.05 (i.e., α-level of 0.05) is considered statistically significant. This also avoids Type II errors at 0.8 (i.e., 1 − β = 0.80), which is considered acceptable [59]. A stricter condition was used in this research study. The used sample size (i.e., N = 416) allowed for a probability of statistical significance at 0.01 (i.e., α-level = 0.01), and significant statistical power (i.e., 1 − β = 0.99). Based on the degrees of freedom (df) used in the conducted tests ranging from df = 1 to df = 12, the calculated effect sizes range from 0.240 to 0.318, respectively. These effect sizes fall between the small and medium effect size range of 0.2 to 0.5 [60,61], respectively. Therefore, the sample size was deemed sufficient for this study. Moreover, representation of the collected sample was also checked by comparing the sociodemographic characteristics of respondents versus characteristics of the targeted population, as will be shown in the next section.

For a general understanding of the collected data, descriptive statistics and graphical representations were used. This is to answer questions such as: What are the sociodemographic
characteristics of respondents? How do their sociodemographics compare to the targeted population? How is background knowledge rated on each of the six RETs? How is willingness to adopt RETs on each of the five willingness perspectives rated?

Subsequently, inferential statistics were used to study correlations between sociodemographic characteristics of respondents and their level of background knowledge on each of the six RETs. Furthermore, it was used to study correlations between sociodemographic characteristics of respondents and their level of willingness to adopt RETs on each of the five willingness perspectives.

For this statistical study, the variables were categorical and the Pearson’s chi-square ($\chi^2$) test was used [62,63]. This statistical test is based on a cross-tabulation technique of frequencies between a pair of categorical variables to test for the significant correlations. A contingency table was generated to test for correlations between each pair of categorical variables using Equations (1)–(3) [59,62,63].

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$  \hspace{1cm} (1)

where,
- $\chi^2$ is the Pearson’s chi-square statistic
- $i$ is the row number in the contingency table
- $j$ is the column number in the contingency table
- $O_{ij}$ is the observed frequency
- $E_{ij}$ is the expected frequency

$$E_{ij} = \frac{RT_i \times CT_j}{n}$$  \hspace{1cm} (2)

where,
- $RT_i$ is the row total
- $CT_j$ is the column total
- $n$ is the total number of observations

$$df = (r - 1)(c - 1)$$  \hspace{1cm} (3)

where,
- $df$ is degrees of freedom
- $r$ is number of rows
- $c$ is number of columns

The statistical significance of the conducted $\chi^2$-statistic was assessed based on the probability level calculated above (i.e., $p < 0.01$) for the used sample size ($N = 416$). The two assumptions of the $\chi^2$-test: independence of data and having a minimum expected count value of five for frequencies in the contingency table [59] were satisfied. The first assumption was satisfied because each of the data points were from a different respondent. The second assumption was also satisfied by ensuring a minimum expected value of five as well as using the Fisher’s exact test to ensure the statistical significance of the $\chi^2$-statistic, in case a minimum expected count was less than five [59,62].

Following this method and using SPSS Version 21.0 [64], correlations among all categorical variables were tested. This was to reveal the significant subsets of the respondents’ sociodemographic characteristics based on level of background knowledge for each of the six RETs and their level of willingness to adopt RETs based on each of the five willingness perspectives. The results of this statistical study will assist in pinpointing characteristics of potential early adopters of RETs, such that better-targeted awareness campaigns on RETs can be designed. It will also reveal the willingness enablers and barriers for adoption.
4. Data Analysis and Results Discussion

4.1. Sociodemographic Characteristics

An approximately equal numbers of males and females took part in this survey, with only 6% more male participants. This assists in the robustness of the study and the results. Table 1 presents the survey participants’ gender profile.

Table 1. Research sample demographics.

| Demographics          | Groups       | Frequency | Percentage (%) |
|-----------------------|-------------|-----------|----------------|
| Gender                | Male        | 231       | 55.5           |
|                       | Female      | 185       | 44.5           |
| Nationality           | Saudi       | 380       | 91.3           |
|                       | Non-Saudi   | 36        | 8.7            |
| Age (Years)           | 18 to 29    | 123       | 29.6           |
|                       | 30 to 39    | 132       | 31.7           |
|                       | 40 to 49    | 87        | 20.9           |
|                       | 50 or more  | 74        | 17.8           |
| Education level       | NA          | 11        | 2.6            |
|                       | Secondary   | 43        | 10.3           |
|                       | Diploma     | 19        | 4.6            |
|                       | Bachelor’s  | 223       | 53.6           |
|                       | Master’s    | 69        | 16.6           |
|                       | PhD         | 51        | 12.3           |
| Monthly Income (SA)   | Less than 5000 | 98       | 23.6           |
|                       | 5001 to 10,000 | 86       | 20.7           |
|                       | 10,001 to 15,000 | 93      | 22.4           |
|                       | 15,001 to 20,000 | 82      | 19.7           |
|                       | 20,001 to 30,000 | 30      | 7.2            |
|                       | More than 30,000 | 27      | 6.5            |
| Employment            | Public sector employee | 143   | 34.4           |
|                       | Private sector employee | 107   | 25.7           |
|                       | Student     | 61        | 14.7           |
|                       | Retired     | 40        | 9.6            |
|                       | Housewife   | 32        | 7.7            |
|                       | Self-employed | 22   | 5.3            |
|                       | Unemployed  | 11        | 2.6            |
| Marital Status        | Married     | 290       | 69.7           |
|                       | Single      | 104       | 25             |
|                       | Other       | 22        | 5.3            |
| Accommodation Type    | Apartment   | 225       | 54.1           |
|                       | Villa       | 161       | 38.7           |
|                       | Other       | 30        | 7.2            |
| Accommodation Ownership| Owner      | 222       | 53.4           |
|                       | Rental      | 158       | 38             |
|                       | Other       | 36        | 8.7            |

The majority of participants had received a bachelor’s degree (54%), followed by master’s degree holders (17%), and then Doctor of Philosophy degree holders (12%). Thus, 83% of participants received degrees in higher education. The remainder of the participants (17%), were secondary degree holders (10%) and diploma degree holders (4%), with 3% having no educational degrees. The participants’ educational level profiles are presented in Table 1.

As part of the study, it was important to investigate the perception of both Saudi citizens and non-Saudi residents on the subject. The majority of participants were Saudi citizens (91%). Table 1 presents the nationality profile of the survey sample.
In terms of participants’ monthly income, which has a significance influence on purchasing power, Table 1 shows the monthly income profile of participants. It shows that the highest number of participants had the lowest income of less than SR5000 (24%), and the least number of participants had the highest income of more than SR30,000 (6%). The distribution of participants with respect to monthly income for the remainder of groups was adequate, with 21% of participants at SR5001 to SR10,000, 22% at SR10,001 to SR15,000, and 20% at SR15,001 to SR20,000. Similarly, to those with the highest monthly income, 7% of participants has an income of SR20,001 to SR30,000, which is considered relatively high.

Different age groups of participants were engaged in this study. According to Table 1, the majority of participants were 30 to 39 years old, representing 32% of the sample size. This was followed by 18 to 29 years old at 29% of the sample size. The ages 40 to 49 years old represented 21% of the sample size, and 18% of participants were 50 years old or older.

Participant employment status was identified in this study (see Table 1). The majority of participants were from the public sector (34%) and the private sector (26%). Students did take part in this study and represented 15% of the sample size. The rest of the sample included limited participation of retired, housewives, self-employed, and unemployed at 9%, 8%, 5%, and 3%, respectively.

The study participants’ marital status is presented in Table 1. This figure shows that 70% of participants were married, 25% were single and the remainder of participants (5%) were of other marital status, such as divorced, widowed, etc.

The accommodation type of participants is presented in Table 1. Most of participants lived in apartment units (54%). Those who live in villa units represent 39% of the sample size, and 7% lived in other types of accommodations such as compounds, townhouses, etc.

Participants were asked to state their accommodation ownership status as part of this study. The results presented in Table 1 shows that the majority of participant (53%) own their accommodation units, while 38% rent. The remainder of participant (9%) have other statuses, which may include, living with parents or other family member, on loans, etc.

The sociodemographic characteristics of 416 respondents in the used sample are compared to characteristics of the targeted population of 5,962,503 people aged 19 years or older living in the western region of Saudi Arabia in 2017 (Figure 1). This is to check for level of representativeness of the collected sample. The 2017 population data was adopted from the General Authority of Statistics, Kingdom of Saudi Arabia [65]. Figure 1 compares percentages of demographic groups used in this research study. Despite the higher percentage of Saudi respondents in the sample versus the non-Saudis when compared to population percentages, the sample is representative, because non-Saudi residents are most likely to be a transient workforce, and almost all real estate properties are owned by Saudi citizens.

**Figure 1.** Research sample versus 2017 population demographic characteristics (Western Region, Saudi Arabia). Source: General Authority for Statistics, Saudi Arabia [65].
4.2. Background Knowledge on RETs

Varied results were seen on the participants’ background on the different types of RETs (see Figure 2). The results show that the majority of survey participants were familiar with solar RETs, but were unfamiliar with biomass RETs. Thus, out of the six RETs considered in this study, 76.7% of participants were aware of solar energy, followed by 60.3% of participants being aware of wind energy. Both sea wave energy and hydroelectric energy had very similar numbers at 46.2% and 45%, respectively. Participants with background knowledge on geothermal energy represented 34.9% of the sample. Finally, only 15.4% of participants had a background on biomass energy.

Figure 2. Participants background knowledge on six types of RETs.

4.3. Sociodemographic Characteristics versus Background Knowledge on RET Sources

As mentioned earlier in the Methodology section, the $\chi^2$-test was used to study correlations between sociodemographic characteristics of respondents and the level of background knowledge on each of the six RETs, as well as willingness perspectives to adopt RETs. Table 2 presents only statistically significant correlations between all tested sociodemographic characteristics and background knowledge. Table 2 reveals statistically significant correlations between educational level and background knowledge on five RET sources (namely solar, wind, geothermal, hydroelectric, and biomass) and between nationality and sea wave RET. Figures 3–7 present bar charts of respondents’ background knowledge on RET sources based on percentages within their educational level categories. Positive correlations between educational level and background knowledge on the five RET sources mentioned earlier are evident from the charts. Figure 8 shows that a higher percentage of non-Saudi respondents have background knowledge on the sea wave RET than Saudi national respondents.

Table 2. Significant correlations between sociodemographic characteristics and background knowledge on renewable energy technologies (RET) sources.

| Sociodemographic Characteristic | Background Knowledge on RET Source | df $^a$ | $\chi^2$ $^b$ |
|---------------------------------|-----------------------------------|--------|-------------|
| Education Level                | Solar                             | 5      | 16.173 **,c |
| Education Level                | Wind                              | 5      | 20.9712 **,c|
| Education Level                | Geothermal                        | 5      | 29.053 **,c |
| Education Level                | Hydroelectric                     | 5      | 14.018 * ,c |
| Education Level                | Biomass                           | 5      | 15.554 **,c |
| Nationality                    | Sea Wave                          | 1      | 6.673 * ,d  |

$^a$ df: Degree of freedom. $^b$ $\chi^2$: Chi-square statistics. $^c$ Based on Fisher’s Exact statistical significance level (2-sided). $^d$ Exact statistical significance level (2-sided). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.  

Based on Fisher’s Exact statistical significance level (2-sided).
Figure 3. Background knowledge on solar energy source (percentages within educational level categories).  

Figure 4. Background knowledge on wind energy source (percentages within educational level categories).
Figure 5. Background knowledge on geothermal energy source (percentages within educational level categories).

Figure 6. Background knowledge on hydroelectric energy source (percentages within educational level categories).
4.4. Willingness Perspectives to Adopt RET Sources

Participants’ willingness was examined against five perspectives related to RET adoption. The perspectives were: (1) save the environment; (2) own an RET source; (3) change traditional source of energy to an RET source; (4) invest in an RET source infrastructure; and (5) pay more for energy by using an RET source instead of a traditional source. The data analysis in Figure 9 shows that saving the environment was found to be the highest willingness perspective for participants, with a majority of participants (96%) having expressed willingness to save the environment. For owning an RET source,
changing to an RET source and investing in an RET source infrastructure, the participants’ willingness perspectives were similar at 79%, 74%, and 72%, respectively. Only 26% of the participants were willing to pay more for RET sources over traditional sources, meaning the majority are not willing to spend more money to adopt RET sources.

![Figure 9. Willingness perspectives to adopt RET sources (percentages).](image)

4.5. Sociodemographic Characteristics versus Willingness Perspectives to Adopt RET Sources

Correlations between all sociodemographic characteristics and each of the five willingness perspectives to adopt RETs were determined. As presented in Table 3, among all tested sociodemographic characteristics, statistically significant correlations only exist between the employment status of respondent, their age, and their willingness to save the environment. A significant correlation exists between the age of respondents and the willingness to pay more for using RET sources as an alternative to traditional energy sources.

| Sociodemographic Characteristic | Willingness Perspective | df | $\chi^2$ a |
|---------------------------------|-------------------------|----|------------|
| Employment status               | Save the environment    | 12 | 22.257 ** |
| Age                             | Save the environment    | 6  | 14.126 ** |
| Age                             | Pay more for using RETs | 6  | 18.852 ** |

*Based on Fisher’s Exact statistical significance level (2-sided). ** $p < 0.01$.

Figure 10 presents bar charts of respondents’ willingness to save the environment based on percentages within their employment status categories. Results showed that most respondents were willing to save the environment based on employment status. A small proportion of 9.4% and 9.3% of housewives and private sector employees, respectively were neutral to the topic. A very small percentage of 2.5% and 0.9% of retired and private sector employees were unwilling to pay, respectively. Results in Figure 11 show that 4.07% and 7.58% of respondents 18–29 and 30–39 years old were neutral about saving the environment, respectively. Additionally, a very small 1.35% and 0.81% of respondents aged 50 years or older and 18–29 years were unwilling to save the environment, respectively. Notably, none of the respondents aged between 30 and 49 years were unwilling to save the environment.

As presented earlier in Figure 9, a total of 74.5% of respondents (i.e., 35.3% neutral and 39.2% unwilling) were neutral and unwilling to pay more for using RET sources as an alternative to traditional sources. Results in Figure 12 showed that 48.5% of respondents between 30 and 39 years were unwilling to pay more for using RET sources. Furthermore, 47.1% of respondents between 40 and 49 years were
neutral about paying more. Conversely, the largest percentage (34.1%) of respondents willing to pay more for using RETs were 18 to 29 years old.

**Figure 10.** Willingness to save the environment (percentages within employment status categories).

**Figure 11.** Willingness to save the environment (percentages within age categories).
This research study revealed that respondents are more likely to have background knowledge on RET sources in the following order: solar, wind, sea wave, hydroelectric, geothermal, and biomass. Moreover, results revealed that the educational level of respondents was the most significant determinant of background knowledge on RET sources. Respondents were likely to save the environment, own RETs, change from traditional energy sources to RET sources, and to invest in the infrastructure of RETs, with only a small percentage neutral or unwilling. However, it is evident that 74.5% are neutral or unwilling to pay more for using RET sources as an alternative. The results show that employment status and age were the most significant sociodemographic determinants of respondents’ willingness to save the environment. Additionally, age is the most significant determinant of respondents’ willingness to pay more for using RET sources. It worth mentioning that employment status and age may have acted as overarching proxy variables to other variables (e.g., income level, and marital status) in determining the willingness of respondents. Despite the fact that none of the respondents aged 30 to 49 were unwilling to save the environment, it was the most neutral and unwilling group to pay more for the use of RETs. This result is important, especially because this age category represents 53% of the total sample size.

5. Conclusions

Results of this research study disclose the status of the background knowledge on six RETs and the willingness of adoption in the western region of Saudi Arabia. The contribution of this study is the revealed information on: how respondents rated and ranked their level of background knowledge on RET sources; their willingness perspectives to adopt RET sources and how they rank them; the significant sociodemographic determinants of background knowledge on RET sources; and the significant sociodemographic determinants of willingness perspectives to adopt RET sources.

Respondents were likely to have background knowledge on RET sources in the following order: solar, wind, sea wave, hydroelectric, geothermal, and biomass. Results also indicate that the main factor influencing the willingness to adopt RETs is economical. Further, results revealed that the most significant sociodemographic determinant is the educational level of respondents. This finding indicates that education is paramount for increasing the level of awareness on RETs. Moreover, findings revealed that the employment status and age of respondents were also significant sociodemographic
determinants of their willingness to save the environment and pay more for using RET sources as alternatives. The analysis showed that younger respondents aged 18 to 29 were more likely to be early adopters of RETs. Furthermore, respondents aged 30 to 49 are the targeted group for changing perceptions on the adoption of RETs and awareness campaigns showing the economic benefits of adoption.

The novelty of this research lies on prevailing the economic importance in the shift from fossil fuel energy sources to RETs. Both the government and the public in Saudi Arabia can realize such economic benefits. From the government perspective, the economic benefits will be mainly realized in the decreased local consumption of fossil fuels to generate energy and exporting the resulted savings, thus increasing government financial returns. Furthermore, this shift will contribute in saving the environment and reducing the negative impact and associated costs with fossil fuel emissions (i.e., public health and pollution, etc.). From the public perspective, the economic benefits can be realized in various forms such as reduction in energy bills, potential feed-in-tariffs returns, and potential government incentives and subsidies.

Implications of this research study include assisting energy policy-makers, government agencies, and RETs investors in designing better-targeted public awareness and marketing campaigns on RETs. This research contributes significantly toward achieving the recently launched National Transformation Program 2020, which is a smaller part of the larger Vision 2030.

Despite a sufficient sample size in this research study, a larger sample size could be collected to validate the sociodemographic characteristics, background knowledge on RETs, and willingness for adoption. The results of this study are considered representative of the public in the western region of KSA; however, the same study could be repeated in different regions of KSA or in different countries. Cross-sectional data were used in this study, but longitudinal data could be used to study the changing status of adoption willingness over time. Currently, studies of more detailed factors influencing the adoption of RETs are in progress.

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