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An exploratory of residents' views towards applying renewable energy systems in Saudi dwellings

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Abstract

Saudi Arabia is experiencing a rapid growth in the demand for energy and residential buildings. The residential sector alone is responsible for over 50% of the total national electricity consumption. The energy supplies in Saudi Arabia are completely reliant on fossil fuels that are regarded to be the main source of greenhouse gas emissions. In order to promote sustainable development it is vital for Saudi Arabia to reduce the usage of fossil fuels. The country is yet to meaningfully explore the renewable energy recourses. Public perception is a key factor in the take-up of renewable energy in any society. Given the importance of the residential sector in the energy scenario of Saudi Arabia, the presented work aimed to investigate the acceptability of renewable energy systems (RESs) amongst the domestic users through a questionnaire based survey. It covered three RESs including solar photovoltaic (PV), micro-wind turbines and solar water heaters. The results revealed that, solar PV is the most preferred choice.

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Keywords: Renewable Energy Systems; Residential Buildings; Solar Photovoltaic; Micro-Wind Turbine; Solar Water Heater; Saudi Arabia.

1. Introduction

The world faces a string of serious energy and environmental challenges. Fossil fuel reserves, presently contributing to over 80% of the world's total primary energy consumption, for example, are declining, the demand for energy is on a steep rise and energy prices are fluctuating and rising [1,2]. The global primary energy consumption is reported to have increased by 29% from 2000 to 2010 and is forecasted to see a further 20% jump by 2020 [3]. In Saudi Arabia, the energy supplies are completely reliant on fossil fuels and electricity generation is based upon oil and gas power plants [4]. The country is experiencing a rapid growth in energy demand. Since 1990, for example, the demand has increased at an annual rate of 6% [5].

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To cope with the stresses caused by the economic and population growth, statistics suggested that the country plans to increase power generating capacity from the current level of about 55 gigawatts (GW) to 120 GW by 2020 [6]. The residential sector is the biggest consumer of electricity – it accounts for over 50% of the total national electricity consumption [4]. Furthermore, the residential sector is set to experience a rapid growth in coming year as the Saudi population is rising at a rate of 2.5% per year and only 24% of the Saudi nationals have their own homes [7]. Also, statistics suggested that around two-third of the population is under the age of 30 years [8]. To meet the needs of the constantly growing population, the country needs to build 230 thousands new homes annually through to 2020 [9]. It is therefore crucial to move towards sustainability by switching to energy-efficient and environment friendly practices and by exploiting the renewable energy resources in the country [10]. The Saudi building industry in general and the residential sector in particular can play a vital role in this respect [11]. However, there is uncertainty regarding the acceptability of the renewable energy systems (RESs) by Saudi residents [12]. The present work therefore aims to explore the Saudi residents' views towards applying these systems in their dwellings through conducting a questionnaire survey.

2. Potentials of renewable energy in Saudi Arabia

Saudi Arabia has a healthy potential for renewable energy especially for solar energy [13,14]. Fossil fuels, owing to their abundance and cheap availability remain to be the main source of energy in the country [13]. Since 1970s, many studies have shown the potential of solar and wind energy in the country but these technologies have not been exploited yet in any meaningful way.

The geographic location of Saudi Arabia is ideal for harnessing solar energy. According to the Saudi Solar Radiation Atlas, the country annually receives around 3,245 sunshine hours accounting for an annual solar radiation figure of over 2,200 kWh/m² [15]. The country can be classified into five inhabited climatic zones represented by Dhahran, Guriat, Riyadh, Jeddah and Khamis Mushait [16]. The weather records for these climatic zones have shown that the annual global solar radiation level ranges from 1,715 kWh/m^2 (in Dhahran) to 2,275 kWh/m^2 (in Jeddah) while the number of sunshine hours varies from 2,698 (in Khamis Mushait) to 3,397 (in Riyadh) [17]. The monthly data showed that the solar radiation level varies between 170kWh/m^2 (in Dhahran) and 250 kWh/m^2 (in Guriat) during the summer months and between 90 kWh/m^2 (in Guriat) to 190 kWh/m^2 (in Khamis Mushait) during the winter months (see Fig. 1a). The monthly sunshine hours were observed to vary from 165 (in Khamis Mushait) to 383 (in Riyadh) during the summer months and from 181 (in Guriat) to 236 (in Riyadh) during the winter months (see Fig. 1b).

Since 1970s, a number of research projects have been undertaken to evaluate the prospects of solar energy for applications like solar water heating, solar distillation of water, solar air heating, solar cooking, solar drying of agricultural produce and other product, solar lighting, solar refrigeration, solar water pumping, solar powered communication, and solar transport [18]. These studies have shown promising results for application of technologies like solar photovoltaic (PV), solar water heater (SWH) and solar drying while options like solar refrigeration and seawater desalination face some technical and economic barriers [18].

One of the earliest solar energy projects in the country was the development of solar village in 1981. At the time, it was a major research project - with 0.35 MW capacity of solar PV - located about 50km northwest of Riyadh [19]. There were however no considerable follow up developments until recent years. The total installed capacity has increased from 0.5 in 2002 to about 16 MW in 2014 [20].

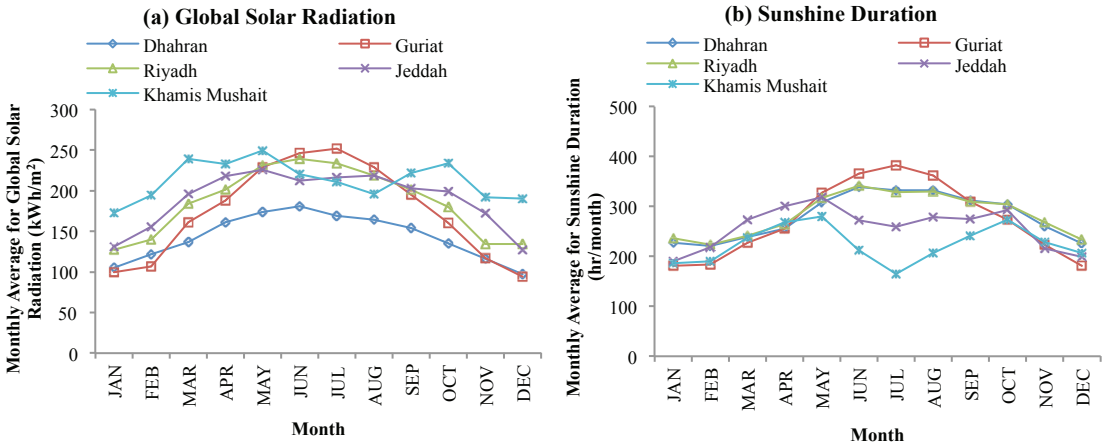

Fig. 1. (a) The monthly global solar radiation in the five main climatic zones of Saudi Arabia [17]; (b) The monthly sunshine duration in the climatic zones of Saudi Arabia [17]

Saudi Arabia has vast open terrain as well as a long coastline, with significant potential for wind power. Amin & El-Samanoudy [21] conducted one of the earliest studies in this respect, which highlighted the two vast windy regions along the Arabian (Persian) Gulf and Red Sea coastal areas. A study undertaken by Rehman & Ahmad [22] showed that the mean annual wind speed at 50m above ground level is 6.7 m/s over Yanbu (Red Sea). Their study also showed that the higher values of monthly mean wind speed for Yanbu - ranging from 7.1 to 7.8 m/s - are in summer months, complementing the greater load demand on national electric grid. For micro-generation, Guriat appeared to have some potential during the summer months while all other regions failed to exhibit any considerable wind resource for the application of micro-wind turbines (see Fig. 2).

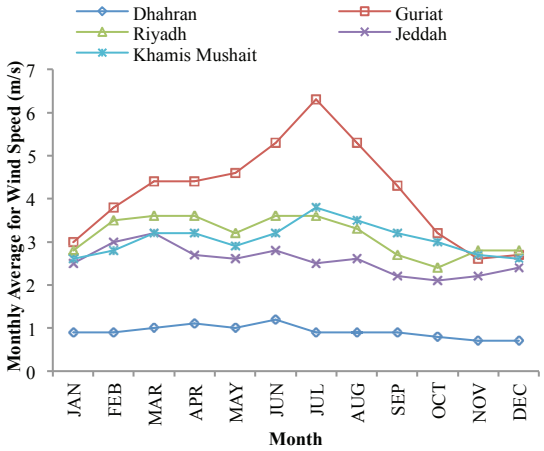

Fig. 2. The monthly average wind speed in different climatic zones of Saudi Arabia at 10m above ground level [17]

Studies have been carried out on geothermal energy resources as early as 1980s [23]. These studies have indicated ten thermal springs in the western part of the country [24], however, more specific work in terms of their quality and quantity is yet to be done [25]. In terms of biomass, due to factors like aridity, water scarcity and harsh weather conditions, the ability in the country of exploiting the vast swath of land and creating biomass markets is greatly limited [26].

3. Questionnaire survey

The questionnaire comprises of 6 questions covering three RESs: solar PV, micro-wind turbine, and SWHs. The survey targets the Saudi nationals with age of 18 years and above. The required sample size was calculated from equations 1 and 2 as provided by Crano & Brewer [27].

$$n = \frac{Nn'}{N+n'} \quad (1) \qquad n' = \frac{p\,(1-p)}{(SE)^2} \quad (2)$$

Where,

n	the required sample size
N	the population size (the Saudi population in 2012 is 19,838,448) [8]
n'	the first estimated sample
p	the estimated proportion to participants (it was assumed as 0.5 for getting the maximum sample size)
SE	the standard error (assumed 2.5%)

The sample size required for this survey was calculated to be about 400 respondents. Subsequently, more than 2,000 questionnaires were distributed randomly amongst the residents in Saudi Arabia covering 16 major cities in the country. To accommodate wider segments of the targeted participants, the questionnaires were designed both in English and the local language, Arabic. The survey was conducted between December 2011 and February 2012 employing web-based and in-person approaches. The number of participants completed the questionnaire survey is 453.

Firstly, participants were asked about their acceptability for purchasing electricity generated through RESs. In this respect, the results revealed that about half of the participants accepted purchasing electricity from RESs if the price stays the same, while about one third of them accepted even if it is a bit costly than purchasing it from the conventional resources (see Fig. 3).

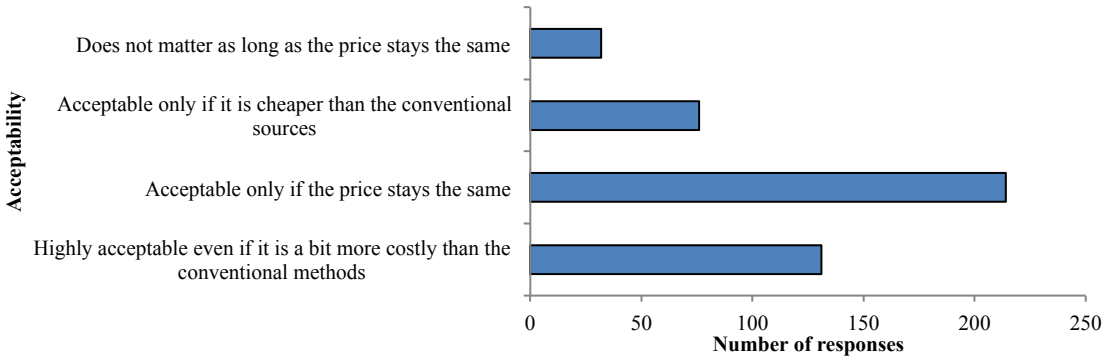

Fig. 3.The participants' acceptability to purchase electricity from RESs

In addition, participants were asked about their acceptability of integrating solar PV panels and micro-wind turbines within their dwellings. The results showed high acceptability from residents to integrate these two RESs. Only 4% and 11% of participants have rejected the application of solar PV and micro-wind turbine respectively (see Fig. 4a). Overall results indicated that solar PV system is more attractive to participants than micro-wind turbines (see Fig. 4a).

The participants were also asked about the number of SWHs in their current dwellings and the possible number in their inspired/future dwellings. The results revealed that the use of SWHs is not attractive as only 4% of participants are using SWHs in the current dwellings and 73% of them are not interested to use the system in the inspired/future dwelling (see Fig. 4b).

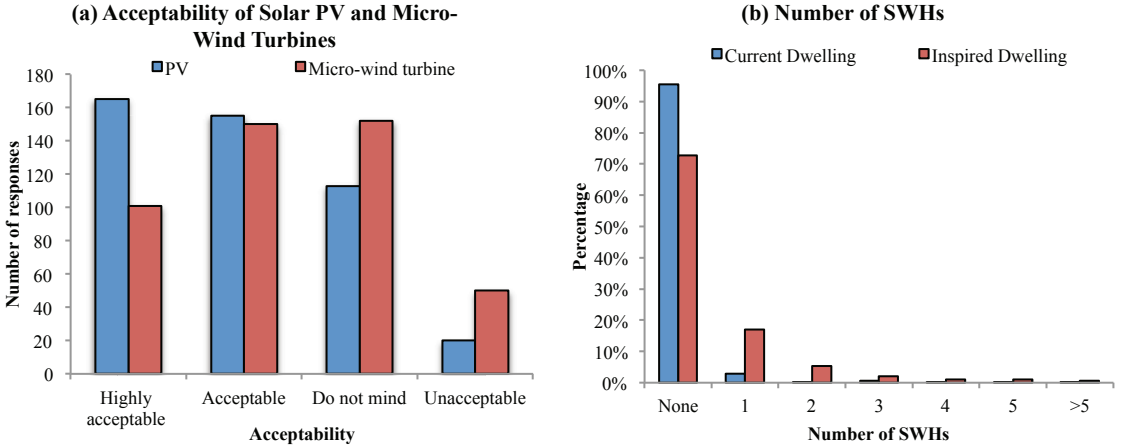

Fig. 4. (a) The participants' acceptability of using PV and micro-wind turbine in their dwellings; (b) The number of SWHs in the participants' current and inspired dwellings

Subsequently, participants who are not attracted to PV and micro-wind turbines were asked to provide the reason. The replies mainly included:

- These systems are new and uncommon for dwellings.
- Lack of awareness on these systems.
- High capital cost of these systems.
- Lack of information concerning performance, durability, reliability and cost effectiveness of these systems.
- Capacity issues with micro-renewable system.
- Uncertainty about their adaptability in the Saudi climate.
- Lack of acceptability of them due to aesthetic aspects.

4. Conclusions

Saudi Arabia has a healthy potential for renewable energy. The weather data in this regard indicate that solar energy is more promising than wind power, the former accounting for an annual solar radiation figure of over 2,200 kWh/m². This work has explored the Saudi residents' views towards solar energy and wind power technologies in their dwellings through a questionnaire survey. The survey results reveal that solar PV and micro-wind turbines are attractive to Saudi residents, as only 4% and 11% have rejected

them respectively. The survey also reveals that solar PV is the preferred choice of Saudi residents compared to micro-wind turbines, while SWHs are the least attractive to them. The findings of the work also reveal that almost one third of the survey-participants are willing to purchase electricity generated from RESs even if it be more expensive than the conventional energy. However despite the interest shown by Saudi residents in these technologies, awareness in the wider society about RESs still remains to be an issue. In order to promote RESs for Saudi dwellings, it is essential to quantify the uncertainties associated with the cost-effectiveness, the technical performance, and climatic adaptability of these systems in Saudi Arabia.

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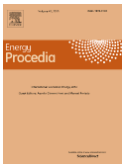

Biography

Alrashed earned an MSc in civil engineering and construction Management from Heriot-Watt University. He is currently a PhD student at Glasgow Caledonian University in the area of Zero-Energy Homes. His research interests are sustainable and energy-efficient buildings.