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Challenges Facing Solar Panel Energy Deployment within Qatari Homes and Businesses

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ABSTRACT

Despite many factors conducive to renewable energy investment in Qatar (e.g., the fact that the state is a major gas exporter whose long-term prosperity depends on economic diversification), there is very low uptake of solar panel adoption among home and business owners. Major challenges implicitly face the deployment of solar and other renewables in Qatar, this research explores possible challenges. The study was conducted in two phases: interviews to identify challenges and using the outcomes from the interviews to obtain a wider response. This study identifies the key major challenges facing the deployment of solar panels in Qatar, which are very useful for diverse stakeholders, policymakers, and future researchers.

1. Introduction

Qatar is a wealthy Gulf Cooperation Council (GCC) country whose national economy is heavily over-reliant on gas exports. It is the world's largest supplier of high-quality natural gas [1]. Qatar has extreme solar exposure throughout the year, making it latently amenable to excellent Renewable Energy (RE) harvesting, particularity solar energy [2]. As shown in Figure 1, Qatar has 4380 overall sun hours annually. July has the highest exposure by month, with an average of 417 hours of sunshine, while February has the lowest, with an average of 312 hours [3]. In addition, the expected value for direct normal irradiance (DNI) is 2,008 kWh per m2 per year, which is around 200 kWh higher than the minimum threshold of 1,800 kWh per m2 per year [2].

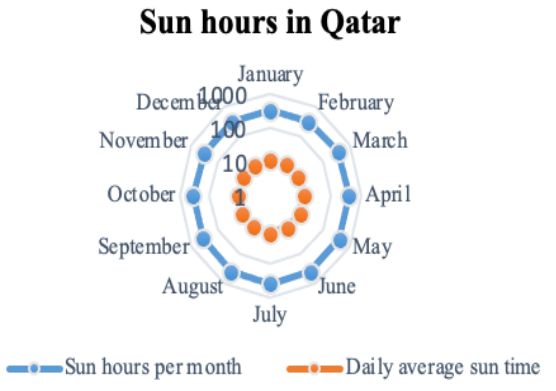

Figure 1. Daily & Monthly Sun hours in Doha, Qatar

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According to Qatar 2030 vision, steps are in place to become a global leader in solar power generated RE, including the goal of achieving 2~4 GW of solar energy by 2030, in order to decrease CO2 emissions by 5 MPTA [4]. Nevertheless, the effort of moving towards clean energy in Qatar remains tentative. In 2021 Qatar deployed the first large-scale solar power plant at Al-Kharsaah, 80 km west of the capital Doha, which intends to offer sustainable, affordable, and clean energy through supplying the Qatari grid with an initial of 350 MW power, seeking to reach full capacity in 2022, covering around 10% of national electricity needs and achieving a CO2 emissions reduction of nearly 26 million tons [5].

Solar PV installation in homes and businesses in Qatar could contribute significantly to achieving the national clean energy strategy, as they are the major users of electricity in the country. They could contribute massively to sourcing 20% of energy from non-gas sources by 2030, particularly by operating air conditioning systems during daylight hours using solar panels, but related initiatives have failed to take off [6]. Therefore, this study seeks to identify challenges to solar energy deployment in Qatar's homes and businesses.

2. Solar Energy Projects in Qatar

Qatar aims to create more than 1 GW of renewable energy. It has many ongoing projects, mainly focusing on solar power. For example, the Qatari government has also built a 1000 MW solar PV plant in Doha and the Ras Lafin stadiums, which will feature solar technology cooling for the 2022 FIFA World Cup. Additionally, small-scale research on solar ponds for residential cooling was carried out at Qatar University in 1992 [7]. The Arabian Gulf's high average insolation (solar irradiation) rate of approximately 1800 kilowatts per square meter makes solar energy

the most promising renewable option for the entire Gulf region, including Qatar.

Qatar has started an enormous initiative to develop and install solar energy globally. Qatar has several large-scale solar power projects in the works. For example, Qatar General Electricity & Water Corporation (KAHRAMAA) expects to complete a 200 MW solar power plant by 2020. Pathak and Tribune [8]. It's worth mentioning that Qatar's total power-producing capacity was 8,750 MW in 2013, which was 2,700 MW more than the total demand [9]. Furthermore, Qatar's food security programme has called for long-term water desalination utilising solar energy [9]. There have also been a handful of smaller solar panel installations on commercial building rooftops and parking lot blinds [9].

According to the International Energy Agency (IEA), photovoltaics (PV) will provide 11% of world energy consumption by 2050, resulting in a 2.3 Gt decrease in carbon dioxide emissions per year. Existing structures account for more than 40% of worldwide primary energy use. These earnings are also vulnerable to global economic fluctuations, international commerce, political, social, and environmental issues, and fiercely growing rivalry. Large-scale PV facilities for PV energy conversion are built-in arid places with lots of sunlight [10] hours of light every year, 70% of which is bright, resulting in 6 kWh/m^2 per day [11]. The peak energy consumption in the GCC occurs during the day in August and September when air conditioning usage is at its peak and GSR levels are at their maximum for the year [12].

For PV energy conversion, large-scale in 1992, Qatar University conducted small-scale research on a solar pond for domestic cooling [13]. Due to the high average insolation (solar irradiation) rate of around 1800 kilowatt/h per square metre in the Arabian Gulf, solar energy is arguably the most promising renewable alternative for the whole Gulf area, including Qatar [13]. With an estimated 2200 kWh/m^2/y Direct Normal Irradiance and 2140 kWh/m^2/y Global Horizontal Irradiance, Qatar's insolation rates are suitable for estimating PV and CSP potential which are higher than the Gulf average.

The "Siraj Solar Energy" project, scheduled to produce roughly 700 MW of power in the fourth quarter of 2021, is one of Qatar's major solar projects. According to Qatar's energy minister, in January 2020, the government inked a deal with Total, a French energy powerhouse, and Marubeni, a Japanese company, to develop a solar power plant capable of producing 800 MW, or a tenth of the country's peak energy consumption [14]. The Al-Kharsaah solar power plant, which is Qatar's first large-scale solar power plant, will use cutting-edge solar energy technology such as twin panels to conserve space, automated sun-tracking systems, and robotic solar panel cleaning to boost production efficiency and lower operating costs. It is anticipated to be finished in 2022 [14].

Al-Kharsaah Solar PV Independent Power Producer (IPP) Project is located 80 kilometres from Doha, Qatar's capital, is the country's first large-scale solar power plant (800 MWp), reducing Qatar's environmental imprint substantially. The Qatari grid will be equipped with sustainable, affordable, and clean power starting in 2021 with an initial capacity of 350 MWp before reaching its total capacity in 2022. The project will generate around 10% of Qatar's electricity peak demand and reduce the country's CO2 emissions by 26 million tons [15]. On over 1000 hectares, the solar plant will be built and equipped with 2 million bifacial solar modules with trackers, providing substantial power gains and taking advantage of the region's exceptional solar exposure [14]. The solar facility will cover over 1000 acres and feature 2 million bifacial solar modules with trackers, allowing for considerable power increases and taking advantage of the region's excellent sunshine exposure [15]. The Al-Kharsaah Solar PV IPP Project, with an output of 800 MWp, will span 10 km^2 (approximately 1400 soccer fields) and include 2 million tracker-mounted modules [16]. This will allow for significant power improvements by utilising the region's abundant sunlight.

Furthermore, using 3240 installed string inverters will increase yearly production even more by allowing for better tracking of the highest power point at the string level. A semi-automated solar module cleaning system will be installed at the factory every four days to remove dust and sand from each module. Al-Kharsaah power station has an 800 MWp and is projected to be fully operational in the second half of 2022 [17]. It will be constructed in two stages, each with a capacity of 400 MWp. In its first year of operation (P50 Year 1), it is expected to generate almost 2,000,000 MWh, enough energy to power roughly 55,000 Qatari homes [16]. The project will provide 10% of the country's peak electricity demand at total capacity and cut CO_2 emissions by 26 million metric tonnes throughout its lifetime, making it a watershed moment in the country's energy history [16].

3. Developments Barriers in GCC

This section summarizes possible challenges delaying the development of renewable energy in general and solar energy within the GCC and in particular at Qatar, based on analysing eight notable studies.

The first study comprised an up-to-date assessment of GCC solar energy efforts and listed some recommendations for the following key challenges identified: technical challenges, lack of public/private initiatives, dependency on oil and gas, lack of research and development capabilities, lack of legislation and regulatory framework, and inadequate application of building integrated RE technology [18].

The second study examined issues affecting residential rooftop solar panel adoption in Qatar, analysing public levels of awareness and knowledge towards domestic solar systems. The study reported that there was latent acceptance among the general population for using solar energy, but government initiatives were needed to improve awareness, reduce electricity price subsidies, and increase subsidies for solar energy installations [19].

The third study aimed to look at present situation of pollution and renewable energy in Saudi Arabia as per the national development plan, Vision 2030, which seeks to expand renewable energy use and to present possible obstacles facing the deployment of solar and wind energy. It identified the following major barriers to solar energy use:

3.1. Environmental Challenges

Effect of high temperature on performance of solar system, power loss due to UV rate, effect of humidity on solar panel performance, degradation of performance due to dust, possible

damage to solar panels due to dust storms, strong winds, and heavy rain.

3.2. Economics / Managerial Barriers

Low price of natural gas, lack of legal and regulatory framework to support investors, low revenue from renewable energy in comparison to oil, lack of education and training on renewable energy, lack of specialized manpower and issues related to connecting generated renewable to the main grid [20].

The fourth study was conducted to assess the current electricity supply grid in Qatar and to explore the potential of incorporating different renewable energy sources (RES) into the main grid. The study simulation results presented promising possibilities to increase the share of RES in electricity production by up to 80%. Reaching 100% would require the integration of electricity storage systems into the main grid, grid stability and electricity access, availability of significant funding for investment in installations, and effective awareness campaigns [21].

The fifth study aimed to pinpoint the key gaps in the current system and the obstacles facing the development of renewable energy technologies in Kuwait. The study highlighted that Kuwait is unlikely to meet the announced target of 15% of its local energy need from RE generated sources by 2030 due to a lack of effective legal and regulatory frameworks, a lack of support for RE infrastructure, and inadequate financing policies [22].

The sixth study amid to statistically examine the challenges and requirements for renewable energy implementation in the UAE from the opinions of 94 participants. The study found positive attitudes towards governmental efforts and RE infrastructure, and solid public awareness for achieving UAE 2050 RE goals [23].

The seventh study was conducted in Qatar, with an aim to experimentally examine the ecumenical loss due to the solar panels environmental challenge associated with dust. The data from the study showed that without clearing solar panels the output power would be reduced by 43% following six months of exposure to dust with average density of 0.7 mg/m^3, which leads to economic losses if panels remain uncleaned [24].

The eighth study aimed to answer the question of why there is "almost no renewable energy in Oman" and argued that government subsidies for electricity produced from oil and gas resources are a key obstacle to RE technologies development in Oman [25].

It can be summarized from the review of the challenges facing renewable energy in the GCC that they fall within five interrelated key dimensions, as illustrated in Figure 2: technical issues related to the performance of solar panels in the local environment (i.e., dust issues); government initiatives and policies; the low return on investment from RE; low citizen awareness and willingness to adopt renewable energy; and the availability of subsidized electrical energy generated from oil and gas (provided free or at very cheap prices). The key impetus to foster renewable energy in these countries remains with governments; once the right regulations and initiatives are in place, other challenges will dissipate.

Moreover, it can be also concluded that challenges related to; monitoring the execution and sustainability of solar panels energy generation projects, to meet the national and global sited targets might emerge. Therefore, this is need further investigation.

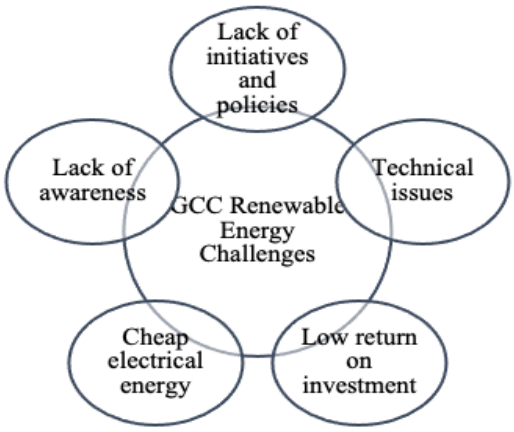

Figure 2. Five key challenges for renewable energy in the GCC countries.

4. Methodology

In order to achieve the main objective of this study, a mixed-method approach was selected, using both qualitative and quantitative methods [26], as illustrated in Figure 3.

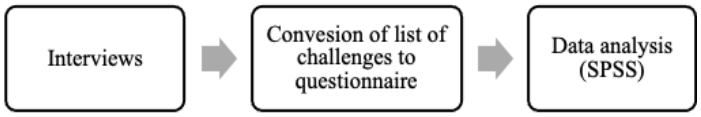

Figure 3. Study research design.

The first method was open-ended interviews conducted by phone with 10 key stakeholders; from the energy sector in Qatar to answer the main question (what the possible challenges are facing the deployment of solar panel energy within homes and businesses) [27]. Qualitative interviews enabled exploring participants' perceptions and experiences in depth, whereby common challenges could be identified from different perspectives. Moreover, the outcomes of these interviews are used to establish the quantitative questionnaire used in the second part of the study. This used Likert-type questions to elicit views from a wider sample, to obtain the opinions of different households and business owners regarding the challenges identified from the qualitative phase. The Likert items assessed participants' level of agreement with the listed challenges, facilitating data analysis [28]. SPSS v.20 is used to analyse the study data, answer its questions, and test its hypothesis [29].

5. Interview Findings

The participants in the interview had the opportunity to see the early listed Five Key Challenges for Renewable Energy in the GCC Countries as showed in Figure 2. Then have been asked two questions. The first question, if they still these challenges are valid for Qatar. While the second question was if they wanted to add any other challenges.

After that, Thematic analysis [30] was the most suitable analysis method to analyse participants' responses from different interview sessions, has been used keeping the first five main themes as listed early and new ten themes have been established,

that led to identification of the following common challenges to solar panel adoption among homeowners and business owners in Qatar:

- There is a lack of awareness of renewable energy
- There are safety concerns of solar panel installation
- Solar panels give low return on investment
- The upfront cost of solar panel installation is high
- There is a lack of available solar panel technology
- There are possible cultural barriers to solar panels installation
- There is a lack of interest due to the availability of other sources of energy
- There is a lack of government initiatives
- There is fear of damaging buildings
- There is fear of changes in the look of the building due to installation
- There is a lack of technical support for solar panels
- There are barriers related to connecting generated energy to the main electrical power grid
- Unclear law and regulations governing solar panels
- There is a lack of environmental interest
- Subsidized conventional electricity makes RE uncompetitive

5.1. Findings from Questionnaire

Using SPSS [29] enabled reliability testing of the quality of responses, generating descriptive data with mean and standard deviation (SD) values, to provide a general overview of the results from each group. One-way analysis of variance (ANOVA) was used for comparative analysis between different groups, to establish any significant differences. The following statistical assumptions were used as shown in Table 1.

Table 1: Descriptive statistics of the data.

Descriptive statistics:

Frequencies and percentages: To measure the distributions of the characteristics of the sample members.

Mean: to measure the average answers of the sample members to the questions of the study questionnaire, which used a five-point Likert scale, weighted as follows:

Score	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Approval	5	4	3	2	1
Relative weight	81~100%	61~80%	41~60%	21~40%	1~20%

Length of the period =	Upper ~ lower	=	5 ~ 1	1.33
	The number of levels		3	

Number of levels:

Level	Period
Low	1 ~ 2.33
Medium	2.34 ~ 3.67
High	3.68 ~ 5

Standard deviation (SD): to measure the dispersion of the answers of the sample members from their arithmetic mean

Inferential statistics:

One Way ANOVA

Consistency coefficient (Cronbach Alpha) for the variability of the stability of the study instrument

5.2. Reliability of the Study Sample

To avoid the data collection method shortcomings when participants fill the questionnaire, it was essential to perform reliability of the study sample. Hence, SPSS Cronbach's alpha reliability was test conducted, its impotent that Cronbach's alpha coefficient needs to be at least 0.6, which indicates that the questions from the questionnaire measure the appropriate variables, signifying a consistent and dependable instrument. The Cronbach's alpha coefficient of the survey used in this study was 0.88, indicating good valid for study purposes [4].

5.3. Data Analysis

Participant characteristics (i.e., their status as either home or business owners, or both) are shown in Table 2. It can be seen that the majority of the same were exclusively homeowners (n = 804, 70.5%), a quarter were exclusively business owners (n = 276, 24.2%), and a small proportion (n = 60, 5.3%) owned both homes and businesses.

Table 2: Nature of the Ownership of the Study Sample.

Nature of ownership	**n**	**%**
Business owner	276	24.2
Homeowner	804	70.5
Home and business owner	60	5.3
Total	**1140**	**100.0**

Table 3 shows the means, SDs, percentages, and degrees of participant responses concerning challenges facing the deployment of solar panels in Qatar. The average score for all items (3.38) indicates a medium level of challenges, and most of these related to "a lack of interest due to the availability of other sources of energy, the availability of subsidized conventional electricity, and there is a lack of awareness about renewable energy," which received high scores. The remaining challenges were as follows: "There is a shortage of government initiatives, there is a lack of environmental concern, there is a lack of technical support for solar panels, there are barriers related to connecting the generated energy to the main electric power grid, law and regulations are unclear regarding solar panels, there is the possibility of cultural barriers to the installation of solar panels, the upfront cost of solar panel installation is too high, there is a lack of available solar panel technology, the solar panels give a low return on investment, there is a fear of changes in the appearance of the building due to installation, there is a fear of safety when considering solar panel insulation, and there is a fear of damaging buildings," which got medium degrees of agreement.

Researchers believe that, this result is due to the fact that it is natural and in any country that if there is free availability of electricity or its cost is very cheap, this will be a direct reason for not installing solar panels, so the person will not bear the burden of the cost of installing solar panels, as he will consider it unprofitable for home or business owner in the future, because electricity is available at a cheap cost, and in this case there will be no benefit from installing solar panels in terms of reducing the cost for the user.

Table 3: The Challenges Facing the Deployment of Solar Panels in Qatar.

Challenges	Mean	SD	%	Degree
Lack of interest due to availability of other sources of energy	4.03	1.261	80.6	High
Subsidized conventional electricity makes RE uncompetitive	3.74	1.401	74.7	High
There is a lack of awareness of renewable energy	3.68	1.284	73.7	High
There is a lack of government initiatives	3.62	1.275	72.4	Medium
There is a lack of environmental interest	3.52	1.231	70.3	Medium
There is a lack of technical support for solar panels	3.48	1.239	69.7	Medium
There are barriers related to connecting generated energy to the main electrical power grid	3.45	1.255	69.1	Medium
Unclear law and regulations governing solar panels	3.40	1.252	68.0	Medium
There are possible cultural barriers to solar panels installation	3.35	1.344	66.9	Medium
The upfront cost of solar panel installation is high	3.26	1.348	65.3	Medium
There is a lack of available solar panel technology	3.26	1.409	65.3	Medium
Solar panels give low return on investment	3.16	1.309	63.2	Medium
There is fear of changes in the look of the building due to installation,	2.96	1.399	59.2	Medium
There are safety concerns of solar panel installation	2.89	1.302	57.9	Medium
There is fear of damaging buildings	2.87	1.332	57.5	Medium
Average	**3.38**	**0.842**	**67.6**	**Medium**

Table 4: One-Way ANOVA to Test the Study Hypothesis.

	n	Mean	SD	df	Mean Square	F	Sig.
Business owner	276	3.37	0.824	2	0.310	0.438	0.646
Homeowner	804	3.39	0.843				
Combined	60	3.28	0.907				
Total	1140	3.38	0.842				

5.4. Test of Study Hypothesis

To test the study hypothesis (H0): There is no different due to the nature of ownership (at the level of statistical significance $p \leqslant 0.05$) in the degree of challenges facing the deployment of solar panels in Qatar. One-way ANOVA results are shown in Table 4, indicating that the F value is not statistically significant ($p \leqslant 0.05$), so we conclude that the nature of ownership does not significantly affect the degree of challenges facing the deployment of solar panel in Qatar.

The researchers believe that, the reason behind this result is that all people when taking any step towards a specific business, the first thinking will be about the material cost of it and whether there is a need for it and future results that result in financial savings, and this thinking is prevalent among everyone regardless of the nature of ownership, as everyone They will agree on the same challenges that they will face in the event of installing solar panels.

6. Conclusion

As anticipated from the main objective of this study, there are various key challenges facing the deployment of solar panels in Qatar, with no differences in degree according to the nature of ownership. The top five major challenges identified from this study are summarized in Figure 4.

It is clear that these top challenges are in line with the main challenges facing RE in other GCC countries. These and the other challenges remain to be tackled before considering deploying solar panel energy for houses and businesses in Qatar, with a national roadmap toward a sustainable energy profile within the medium to long term. In addition of setting further agenda future research. Moreover, the outcomes from this study can be useful for other stakeholders in other GCC countries to revisit their own challenges and see if new emerged ones are worth consideration.

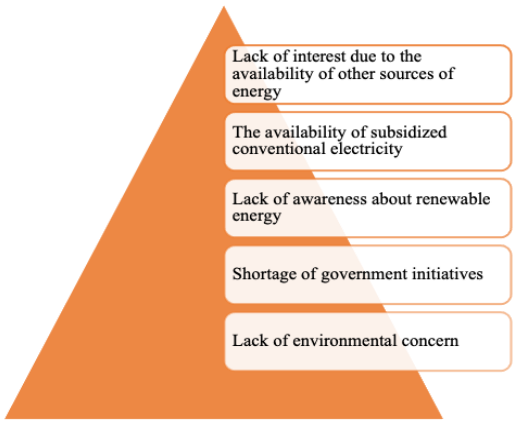

Figure 4. Five key challenges.

Conflict of Interest

The authors declare no conflict of interest.

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