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## **Challenges towards Renewable Energy: An Exploratory Study from GCC Region**

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**Abstract:**

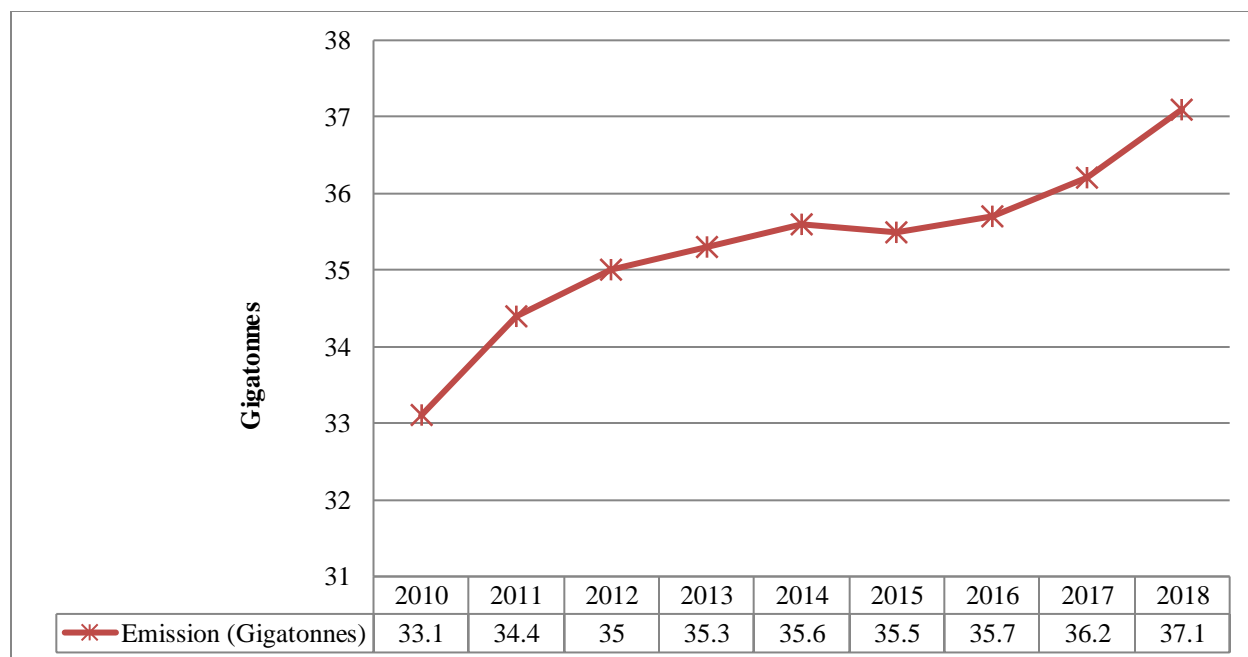
Considering the importance of energy for social and economic development, access to clean, affordable and reliable energy has been adopted as one of the UN Sustainable Development Goals which all countries aim to achieve by 2030. Due to environmental and climatic impact, conventional energy resources (oil, gas, and coal) are recognized as a major contributor to CO<sub>2</sub> emission and thus become the main cause of global warming. Much of the world energy is still, however, produced from fossil fuels and thus the progress towards clean and renewable energy is considerably slow. This article aims to explore the key challenges towards renewable energy in GCC countries-blessed with plenty of oil and gas reserves. The key challenges identified through the literature review were ranked using a quantitative approach through the data collected from a selective sample (N = 87) across the six GCC countries. These challenges as per their ranking are (i) Policies and Regulations, (ii) Manpower Experience and Competencies (iii) Renewable Energy Education (iv) Public Awareness (v) Costs and Incentive for Renewable Energy (vi) Government Commitment. The finding of this article could be helpful to

decision-makers and government organizations in the region to develop strategies to overcome these identified challenges.

**Keywords:** Energy, Renewable energy, Energy conservation.

## **1. Introduction:**

Although energy has become an integral requirement of today's modern life and it is considered as a fundamental element for social and economic growth, however, the United Nations report indicated that 13% of the earth's populations still have no access to modern electricity. Similarly, more than 3 billion people still on wood, coal, charcoal or animal waste for cooking their food and heating purposes. Energy is considered as the dominant contributor to climate change, which is estimated for around 60% of total global greenhouse gas emissions. Similarly, it is estimated that in 2012, the indoor air pollution from using combustible fuels for household energy caused 4.3 million deaths around the world (WHO, 2018). Overall, most of the current energy production is based on conventional resources such as oil, gas, and coal which on the one hand are non-sustainable but also, on the other hand, these resources produce greenhouse gases. These gases are considered a threat to the earth due to its contribution to global warming and climate change. The main gas which highly contributes to global warming and climate change is CO<sub>2</sub>. The emission of the CO<sub>2</sub> to the earth's atmosphere has been significantly increased since 1950 which has reached a level of 400 parts per million (ppm). The CO<sub>2</sub> emission during the past 800,000 years until 1950 was below the level of 300 ppm (Lindsey, 2018). Majority of the greenhouse gases are regarded as manmade gases in which the major role has been played by the recent industrialization. Although, the issue of global warming and climate change is well regarded as a threat to human life on the earth and there have been several efforts to control the emissions which cause global warming and climate change, the data from different sources reflect that these emissions are still increasing (Umar et al., 2019-a). For instance, the global CO<sub>2</sub> emission from fossil fuels in 2010 was 33.1 gigatonnes which have increased to 37.1 gigatonnes in 2018, representing a total increase of 12.08% as shown in figure 1. This emission quite alarming and if not tackled properly, and if it is increased at the same level, it would reach 41.58 gigatonnes by 2028.



**Figure 1: Global CO<sub>2</sub> Emission from Fossil Fuels [2010 – 2018] (WRI, 2018)**

Similarly, as the population on the earth is gradually increasing, the future energy requirement could be huge and would not be met only through conventional energy resources. Kibert (2016) estimated that if all 7.3 billion of Earth’s people consumed at the same rate as the average American, it would take six planets to support them. All these facts have attracted the attention of the world leaders at different forums including the United Nations where energy was placed among the 17 sustainable development goals adopted by in 2015. All member countries of the United Nations agreed to achieve these goals by 2030 (United Nations, 2015). The goal 7 of the United Nations sustainable development goals is “Affordable and Sustainable Energy” under which the member countries agreed to ensure access to affordable, reliable, sustainable and modern energy. This goal is further supported by five universal targets as mentioned below:

Target 1: By 2030, ensure universal access to affordable, reliable and modern energy services.

Target 2: By 2030, increase substantially the share of renewable energy in the global energy mix.

Target 3: By 2030, double the global rate of improvement in energy efficiency.

Target 4: By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.

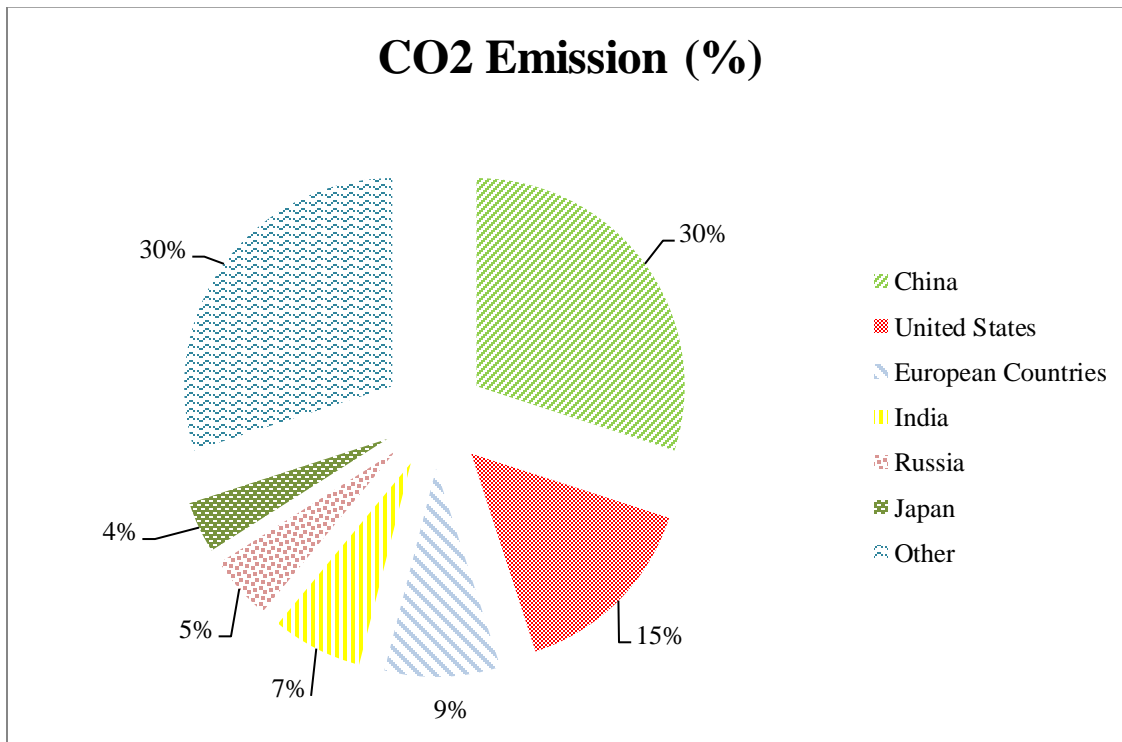
Target 5: By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular, least developed countries, Small Island, developing States, and land-locked developing countries, in accordance with their respective programs of support.

The current United Nations ‘Sustainable Development Goal Report’ on Goal Number 7, shows that renewable energy in the electricity sector has advanced rapidly, accelerated progress is also needed in the areas of transport, heating, and cooling. Despite some steps forward, 41% of the world’s population still lacks access to clean cooking fuels and technologies. Overall, progress on Goal 7 remains too slow to be on track to meet the global energy targets for 2030 (UNSDGR, 2018). Similarly, under the United Nations Framework Convention on Climate Change (UNFCCC) and United Nations sustainable development goals member countries were able to reach on the Paris Agreement. In this agreement, all member countries agreed to work to limit global temperature rise to well below 2 degrees Celsius, and given the grave risks, to strive for 1.5 degrees Celsius. Implementation of the Paris Agreement is essential for the achievement of the Sustainable Development Goals and provides a roadmap for climate actions that will reduce emissions and build climate resilience (COP21, 2015). All member countries are required to submit and publicize their Intended Nationally Determined Contribution (INDCs). These plans display the commitment of the members’ countries towards the reduction of greenhouse gas emissions in their jurisdictions. For instance, China, which is ranked first on the greenhouse gas emission (figure 2), aims to increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030 (China-INDC, 2015; EPA, 2017). It is anticipated that if these plans were to be implemented, the total sustainable energy contribution could grow by nearly 11,000 TWh by 2030. The share of renewable energy in the final energy consumption was 17.5%

in 2015. The United Nations report still indicates that only 55% of the renewable share was derived from modern forms of renewable energy.

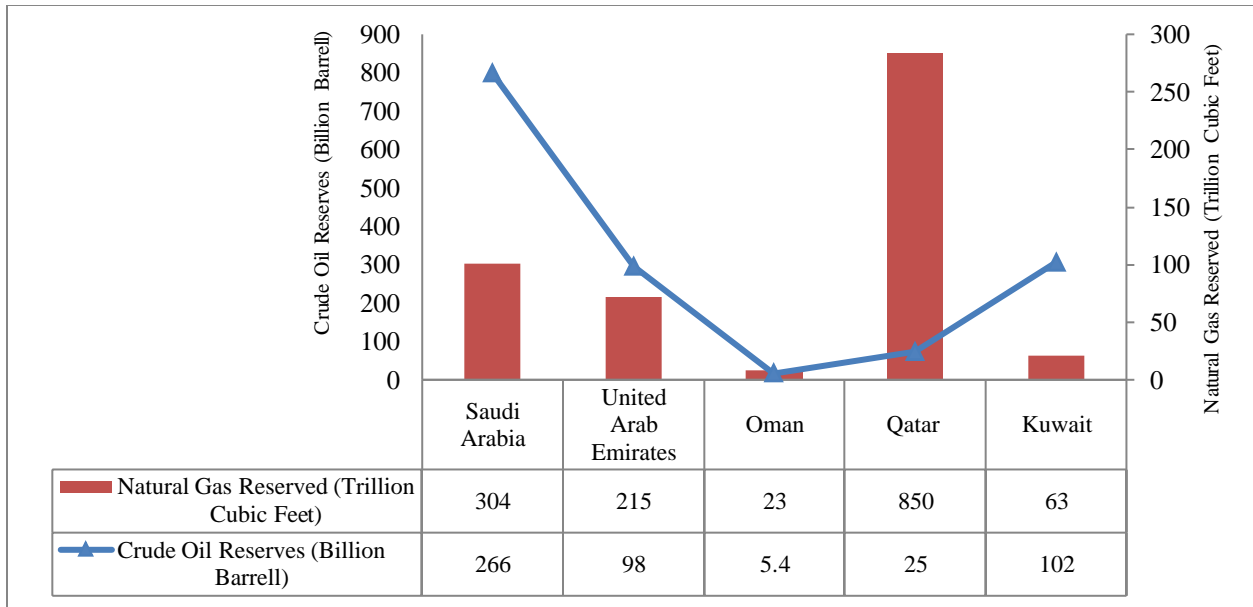
Umar and Egbu while looking into the INDCs of the member countries of United National noted that 53% of these plans are outcomes-based while 27% of the plans are action-based. They further noted that 20% of the member countries have not yet submitted their INDCs to the United Nations (Umar and Egbu, 2018-a). All the member countries of the Gulf Cooperation Council (GCC) which includes Saudi Arabia, United Arab Emirates, Oman, Bahrain, Kuwait, and Qatar were among those countries who have not yet submitted their plans. The United Arab Emirates, however, have reflected some progress towards UN Sustainable Development Goals. In this regard, the establishment of a National level committee that monitors the progress of United Arab Emirates Sustainable Development Goals is among some of the initiatives already in place. Under these initiatives, Dubai government has announced a revision of its targets for the share of renewable energy in the total energy mix to 7 percent by 2020 and 15 percent by 2030 (TFCSA, 2019). Generally, there could be several reasons that why some countries have still not submitted their plan, however in relation to GCC countries, the reason that they are rich in oil and gas reserve is prevailing (figure 3). Highly subsidies fuel and electricity costs in all gulf countries prevent the governments from any type of pressure from the public side to expedite shifting towards renewable sources. This article, therefore, attempts to identify the main challenges which the region is facing towards moving on the renewable and sustainable region. Different challenges that affect the countries' progress in shifting on renewable energy are identified from the existing literature review. A structured questionnaire is then used to know the impact and relevance of these challenges on GCC countries. Universities' lectures and professors working within GCC countries were considered to be the best respondents in this study. The universities and college professors or lecturers were considered to be more suitable respondents based on academic integrity or academic freedom and based on their interest in renewable energy. A mainstay of academic life for professors is professional or academic autonomy, often called simply academic freedom (Aberbach and Christensen, 2017). Academic freedom may be defined as the freedom to conduct research, teach, speak,

and publish, subject to norms and standards of scholarly inquiry, without interference or penalty, wherever the search for truth and understanding may lead (GCUP, 2005). The unique role of the professors and teachers in striving to promote sustainable development was well reported by Ocetkiewicz et al. (2017). In their research on renewable energy in education for sustainable development, they emphasized the social role of the teachers which could lead the process of dynamic social change and increase the adaptability of sustainability and renewable energy. The professors and teachers are not only the translators but they interpret and guide in the world of values (Alexander, 2006). The Mathiesen et al., (2015) quoting “Coherent Energy and Environmental System Analyses” project which was held in Denmark, noted that this project involved more than 20 researchers from seven different universities and research institutions. The adopted methodology is described in detail in the later section. To understand the GCC energy outlook, the region is described in terms of energy context in the next section.



**Figure 2: CO<sub>2</sub> Emissions by Country (Fossil Fuels and Some Industrial Process) – EPA, 2017.**



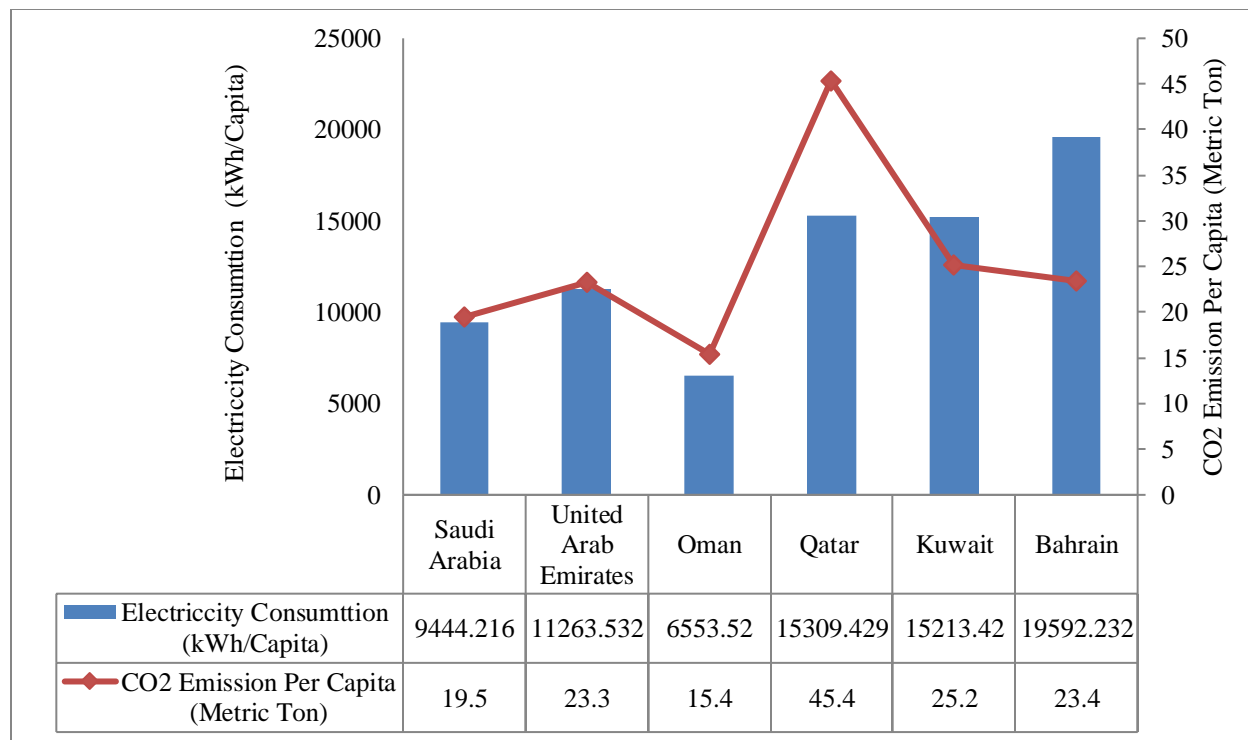


**Figure 3: Oil and Gas reserve of GCC countries (EIA, 2018)**

## 2. GCC Energy Background:

To effectively understand the energy requirement of GCC countries, the electricity consumption and CO<sub>2</sub> emission in these countries are considered in the first instance. As mentioned in figure 3, the gulf region is rich in oil and gas reserves, therefore this region is considered as a main producer and supplier of the energy. The oil and gas revenue constitutes a major portion of the Gross Domestic Product (GDP) in most of the GCC countries and remained support for the government and industrial sectors (Umar, 2016). At the same time, the region is also a main consumer of energy as compared with other countries around the world. Similarly, due to the high rate of electricity consumption in these countries, the CO<sub>2</sub> emission is also high as presented in figure 4. High electricity consumption and CO<sub>2</sub> emission could be justified due to the climatic condition of the region where the temperature in summer reaches 50°C as reported by Umar and Egbu (2018-b), however, such consumption and emission are more than the double when compared with other countries. For instance, the average consumption in GCC countries (=12,896.058 kWh) as of 2014, is more than three times greater than the electricity consumption in China (= 3,927 kWh). Similarly, the GCC electricity consumption per capita is more than double the consumption in the United Kingdom (= 5,130 kWh). It is very difficult to justify so high consumption of electricity in the GCC region based on

the argument that it has a hot climatic condition. if this argument is considered to be true, then a high consumption is to be expected from the United Kingdom as well, as it has a cold climatic condition, however, the consumption in the united kingdom is far low than the average consumption of the GCC. Similarly, the average CO<sub>2</sub> emission is GCC countries (= 25.36 Metric Ton) is more than three times greater than the CO<sub>2</sub> emission per capita in China (= 7.5 Metric Ton) and almost four times greater than the CO<sub>2</sub> emission per capita in the United Kingdom (= 6.5 Metric Ton). The main reason for this high CO<sub>2</sub> emission in GCC countries is that most of the electricity in these countries is produced by oil and gas. For instance, in Saudi Arabia, a total of 330.5 billion kWh of electricity was generated in 2016. 40.30% of this electricity was produced from oil, 59.6% was produced by gas and only 1% was produced from renewable resources (K.A (CARE), 2016). Similarly, according to the British Petroleum report, 68% of the electricity in Oman is produced by gas while the remaining 32% is produced by oil (BP, 2018). Overall, the share of GCC countries in the renewable section is almost negligible. At the same, other parts of the world, research is in progress to explore how to meet the full energy requirement of cities through renewable sources (Honnurvali et al., 2019). Thus it is obviously clear that a huge emission could be expected from these countries when all of its energy requirements will be met from fossil fuels. Different estimates show that 0.0016 barrels oil is required to produce one kWh of electricity and one barrel of oil produces 0.43 metric tons CO<sub>2</sub> (EIA, 2017; EPA, 2018). To clarify the situation more effectively, the total electricity consumption per capita in the GCC region is 77376.349 kWh and the total CO<sub>2</sub> emission in this region is 152.2 Metric tons (=152,200 kg). In other words, the CO<sub>2</sub> production per capita per kWh in the GCC region stands at 1.97 kg (1.97 kg/ kWh). This further reveals that the CO<sub>2</sub> production for China (=1.90 kg/ kWh) and United Kingdom (1.26 kg/ kWh) is lower than the GCC region. The move of the GCC region towards renewable energy may change these figures and could enable the region to reduce its emission per kWh.



**Figure 4: Electricity Consumption and CO<sub>2</sub> Emission Per Capita in Selected GCC Countries (WB, 2014-a, WB, 2014-b)**

Some countries which have more oil and gas reserves than GCC countries have already moved towards renewable resources. For instance, Canada which has 170,000 million barrels of oil reserves and ranked as 3<sup>rd</sup> (as of 2019) after Venezuela and Saudi Arabia, have already installed 2.72 gigawatts solar capacities (BP, 2018). Most of the renewable energy resources such as solar, wind, biomass, geothermal and wave and tidal have a potential for electricity generation in the GCC region, however, these resources are still not yet adopted in a true letter and spirit. There have been a number of recent researches which demonstrate the potential and adaptation of these renewable resources in the gulf region. For instance, Umar and Wamuziri (2016) in their research on renewable energy resources in Oman estimated the wind energy content at several locations in Oman as 4,400 kWh per meter square per year. Similarly, the solar content was estimated as 6.09 kWh per square meter per day. Similarly, Umar (2018-a) and Umar (2018-b) in their recent studies explored the potential of geothermal and biomass for electricity generation in Oman. Of course there are several issues associated with these renewable energy resources, such degradation of power in solar panel, storage and losses during conversion from direct current (DC) into alternating current (AC),

however, there are several solutions already available in this respect (Honnurvali et al., 2018-a). In a recent research Honnurvali et al., (2018-b) concluded that the power degradation rate in Oman is comparatively more due to the hot and humid environment as compared with other parts of the world.

In the presence of several renewable energy resources in the region, the slow progress in the adaptation of these resources is quite questionable. It is, therefore, necessary to explore that what are the main challenges which gulf region is facing in this regard. The next section of the article presents a literature review of the main challenges involved in the renewable energy sector.

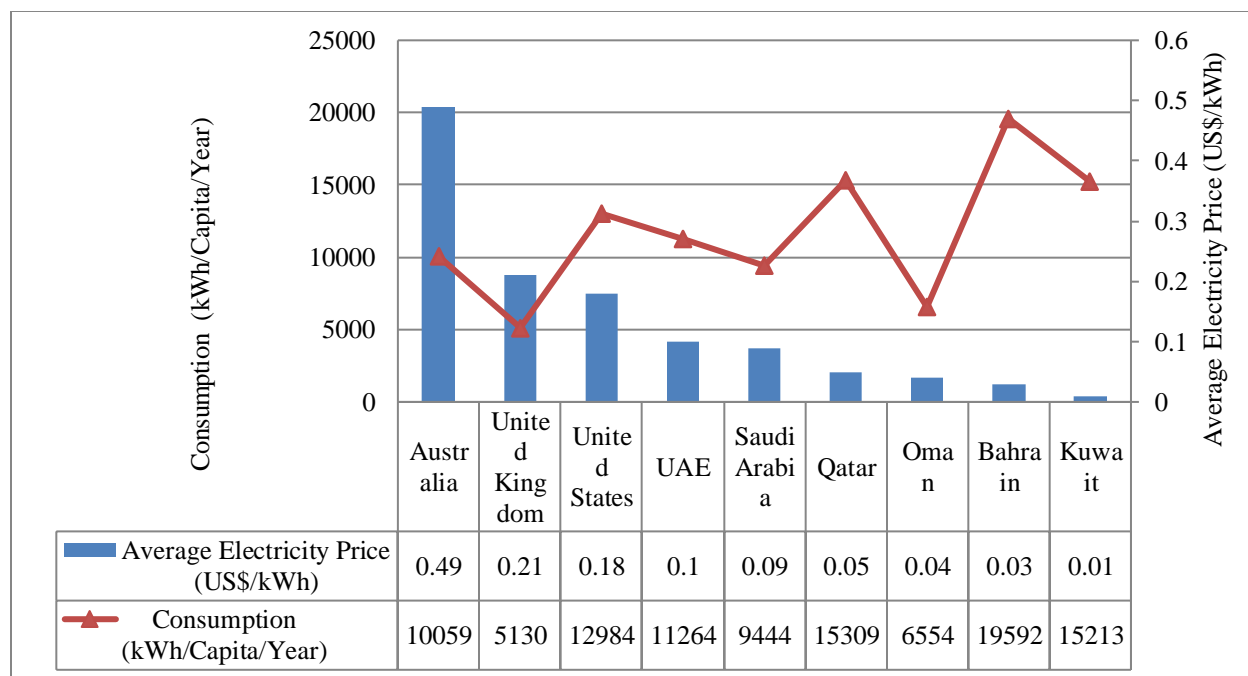
### **3. Challenges in Renewable Energy:**

Different forms of renewable energies have several challenges such as policy guidelines, government commitment, public awareness, cost and integration with the local grid and existing system (Wang et al., 2010; Chu and Majumdar, 2012; Stram, 2016; Liang, 2017). Shifting to any form of renewable energy took place gradually, which means that the existing system of production will remain intact, and the new energy produced will need to be integrated with the existing system. Al-Maamary et al., (2017) considered the government support for electricity and fuel prices as the main barrier in adopting renewable energy such as solar at the individual level in GCC countries. This fact is well established by the electricity tariff in GCC countries. For instance, the subsidies residential tariff of an electricity distribution company in Oman is 10 Bz per kWh (0.026 US\$) for a consumption of 1 to 3000 kWh (table 1). Based on this tariff, if a residential consumer consumed 282 kWh electricity in Oman, the total cost will be equal to 8.46 OMR (= 21.99 US\$), however, the actual bill which the consumer will pay, will be equal to 2.82 OMR (= 7.33 US\$). The situation over other GCC countries is not much different from Oman as shown in figure 5, wherein the GCC tariff and consumption are compared with the United Kingdom, the United States, and Australia. The high consumption and low cost of electricity in the GCC region reflect that there is somehow a lack of policies that can drive towards renewable energy. Such lack in policies was however not evident at the national level. For instance, the Omani Visions, 2020 and 2040 as reported by Umar et al., (2019-b) stress to reduce the dependency on oil and gas (Oman Vision, 2020; Oman Vision, 2040). Similarly, UAE Vision 2021 and

Dubai Integrated Energy Strategy (DIES) 2030, aims to secure uninterrupted energy supply and moderate the growing energy and water demand of Dubai and to increase the sustainability and competitiveness of its economy (DIES, 2030). Qatar also intended to diversify its economy to gradually reduce its dependence on hydrocarbon industries. The 2030 Qatari Vision aims to have a proactive and significant international role in assessing the impact of climate change and mitigating its negative impacts, especially in countries of the Gulf region (Qatar Vision, 2030). The slow progress in achieving the goals mentioned in these visions reflected that these visions are not followed in a true letter and spirit government entities at a lower level. Such lack of commitment is well observed by both local and international organizations in GCC countries. For instance, the International Renewable Energy Agency (IRENA) report developed along with the Masdar Institute and Ministry of Foreign Affairs on the renewable energy prospects of the United Arab Emirates for 2030, clearly highlight the required government actions. The report suggests that the new business case for renewables, however, will not be realized without policy reform and stakeholder awareness. The federal and emirate-level governments will need to clarify their respective responsibilities for project initiation and implementation, regulate the integration of renewable energy technologies where needed, and set timelines (IRENA, 2015). Overall, the above discussion reveals that a clear policy and vision can be an integral part to drive renewable progress in a specific country.

<b>Consumption Residential (kWh)</b>	<b>-</b>	<b>Actual Cost (Tariff in Bz per kWh)</b>	<b>Subsidies Cost (Tariff in Bz per kWh)</b>	<b>Subsidies Cost (Tariff in US\$ per Kwh)</b>
1 to 3,000		30	10	0.026
3,001 to 5,000		45	15	0.039
5,001 to 7,000		60	20	0.052
7,001 to 10,000		75	25	0.065
Over 10,000		90	30	0.075

**Table 1: Residential Tariff in Oman (MEDC, 2019)**



**Figure 5: Electricity Cost and Consumption in Selected Countries (WB, 2014-a; Statista, 2018)**

One of the other factors which could enhance the adaptation of renewable energy sources such as solar at the individual level is the economic incentive. Such incentives were effectively adopted in India which has produced good results and in many countries, the number of prosumers installing rooftop solar PV systems is rising (Couture et al., 2014). Supportive policies are emerging, such as net metering for rooftop solar PV systems, to promote prosumer involvement with the electricity system (the grid). As of 2015, 48 countries, both developed and developing, had implemented net-metering policies (Adib et al., 2015). The support mechanism which includes Renewable Energy Certificates, National Capital Subsidy Scheme, Accelerated Depreciation Benefit and Gross Metering, adopted for solar PV in India, has significantly increased the total electricity production from the solar rooftop (Umar, 2017). The solar rooftop could be adopted in GCC countries which may have a better output than India as solar radiation is comparative more here, however, there could be several challenges rated to building regulation, initial cost, and permission. Generally, if a residential house in Oman consumes average electricity of 800 kWh per month and the solar panels with 265 watts capacity will get full sun for 6 hours; then the total area for solar panels will be equal to 27.81 sqm to meet the house energy requirement. Managing this much rooftop area could be quite challenging,

especially in the existing buildings. Apart from solar energy, there are issues with wind, geothermal, biomass, wave and tidal ranging from availability, capacity, emission, and costs, however; these issues can be addressed when there is government commitment, clear policy, guideline, experienced manpower and competencies.

When it comes to competencies to explore and adopt the appropriate renewable energy resources, the role of renewable education is important. Lucas et al., (2018) outlined that the design, development, and dissemination of appropriate renewable energy technologies is important for meeting the growing energy requirement for economic growth as well as for improvement in the quality of human life. One of the barriers to achieving the expected renewable energy market development is the shortage of qualified human skills. Kandpal and Broman (2014) noted that the existing renewable energy education programmes in general, and university-level teaching/training programmes, in particular, are facing a variety of challenges that include (a) unavailability of well-structured curricula for imparting renewable energy education at all levels, (b) lack of motivated and competent teachers/trainees at all levels, (c) unavailability of adequate funds for establishment of well-equipped laboratories, libraries, etc. and (d) uncertainty on the employment prospects of the student successfully completing these programmes. It is, therefore, necessary that relevant issues pertaining to all the above challenges are thoroughly understood and efforts are made to resolve the same to facilitate efficient and effective renewable energy education in an economic manner.

Based on the above discussion, the key areas which could negatively affect the renewable energy progress in the GCC countries are summarized into the following categories. Knowing these areas will help the decision-makers to develop appropriate strategies and plans to overcome the challenges associated with these areas (Umar and Wamuziri, 2017).

- i. Government Commitment
- ii. Policies and Regulations
- iii. Costs and Incentive for Renewable Energy

- iv. Public Awareness
- v. Manpower Experience and Competencies
- vi. Renewable Energy Education

#### **4. Research Methodology:**

The research methodology adopted for the completion of this research is commonly known quantitative research method. Quantitative research stresses quantification in data collection and examination. It takes a deducible way to the connection among theory and research and stress are kept on the confirmation of theories (Umar et al., 2019-c). The quantitative research method integrates the norms and practices of the natural scientific model and positivism. It views the social phenomenon as an outer objective truth (Cooper et al., 2006; Umar, 2019). Data was collected from a variety of respondents shown in figure 6. University and college lecturers and professors working in government or private institutions in GCC were considered to be the best respondents for this research. Although the participation in the study was on a volunteer basis, the respondents were still ensured that all the data collected will be treated anonymously and will not be shared with any agency or government institution. The respondents were given the option to indicate their names and affiliations on the questionnaire if they wish, however it was not mandatory. Even if the respondents mentioned their names or affiliations, it was coded in the data analysis stage and the filled questionnaires were kept in a highly secured place which can be only accessed by the researchers. This was made clear to the respondents so that their response could not be affected by any hidden thread in their mind and to achieve a high level of reliability of the collected data. The literature review also suggests that university professors and lecturers were considered as respondents in many studies. For instance, Dawson in his research investigated the perspective of university teachers on climate change considering a sample of 39 teachers (Dawson, 2012). Similarly, another study which aimed to investigate the challenges to renewable energy considered the early-stage researchers (PhDs) and professors as respondents. This study also used the quantitative approach and the number of respondents was 122, however, the percentage of professors was only 18% (Zyadin et al., 2014). The questionnaire was distributed only to the lecturers and



professors specialized in engineering. A simple questionnaire was adopted for recording the response of the respondents using a Likert scale. Part I of the questionnaire is related to the personal / background information of the respondents. This information includes the birth year, gender, position/role, academic qualification, specializations, research interest, experience, age group and country of birth. In Part II of the questionnaire, the respondents were asked to rate their responses related to “Government Commitment” on a scale of 1 to 5. (1= strongly disagree, 5 = strongly agree). In part II there is a total of 10 questions. Part III is related to the “Policies and Regulations” and there is a set of 11 different questions. In Part IV, there are 10 questions which are related to “Costs and Incentives for Renewable Energy purposes In part V, which is related to “Public Awareness”, has a set of 8 questions. There are 7 questions in part VI entitle as “Manpower Experience and Competencies”. Part VII of this questionnaire is related to “Renewable Energy Education” and it has 9 questions. The last section of the questionnaire (part XI) is provided for the comments of the participants. The questionnaire was distributed electronically to the selected respondents.

The normality of the data was checked through the ratio between skewness and its standard error, and the ratio between kurtosis and its standard error. The data was considered normal if the ratio was between – 1.96 to +1.96. Briefly, Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. Similarly, Kurtosis is a measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution. That is, data sets with high kurtosis tend to have heavy tails or outliers. Data sets with low kurtosis tend to have light tails or a lack of outliers. The questionnaires received with signed in informed consent were used in the analysis and results. The raw data obtained from the questionnaires were processed using SPSS, data analysis software. To calculate means scores for each element and individual, the raw data from different items were used. As a rule for data analysis, only the answered items of the questionnaire were used. If in a specific dimension or factor, a respondent has answered less than 50% of the items, thus all answers were excluded for that dimension. This was done based on the fact that a mean score based on less than 50% of

items is not considered as valid. A descriptive analysis was carried out to determine the mean score of each element.

## **5. Results and Discussion:**

A total of 200 questionnaires were electronically distributed to 10 higher educational institutions across the GCC region. A total of 87 filled questionnaires were received from the respondents, representing a response rate of 43.5%. A study carried out by Shih and Xitao (2008) analyzed a total of 39 different papers published from 1998 to 2006 which have used the data collection tool administrated through web and paper-based. The results show that the average response rate of the web survey was 33.87% while the paper-based response rate was 44.56%. Since the questionnaire used in this research was a web base and was distributed through email, thus the response rate received (= 43.5%) is considered satisfactory. There have been some studies that used a qualitative approach and interviewed only six respondents (Umar and Egbu, 2018-c; Umar et al., 2017). A recent study in the area of renewable energy conducted by Filho et al., (2019) was based on a sample size of only 50. Similarly, Umar et al., (2018) in their study which aimed to asses the construction worker's productivity and safety performance used a quantitative approach selecting a total of 30 respondents only. The total population (construction workers) in their study was, however, stood at 700,000. Some researchers, however, recommend that the sample size or the response rate needs to be calculated based on the population size (Kotrlík and Higgins, 2001). In some cases, the sample size calculated based on the population size could not be helpful or even not adoptable. For instance, if the population is the 'population of China'; then the sample size calculated through this principle will be very large and thus could not be achieved. The overall participants from different GCC countries are shown in figure 6. No questionnaire was rejected. All of the respondents participated in this survey were expatriate (males = 89.65%, female = 10.34%) belongs to different nationalities as shown in figure 7. Similarly, the respondents were from different age groups and experience as shown in figures 8 and 9 respectively. The specialization of the respondents is given in figure 10. A total of 72 respondents (= 72.75%) reported that they have a research interest in renewable energy.

The sample size was validated using equation 1, considering the following parameters.

$$N = \left(\frac{z\sigma}{d}\right)^2 \dots\dots\dots\text{Equation 1.}$$

Z = 1.96

Standard deviation ( $\sigma$ ) = 7.10 (calculated from age of respondents using SPSS program)

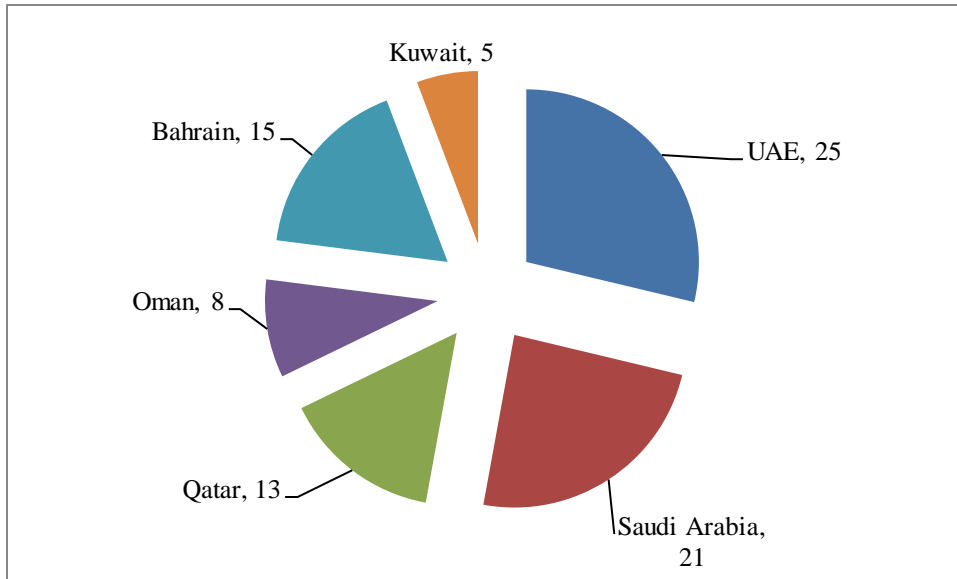
Error (d) = 1.71 (5% of the mean value of the age)

Based on these parameters, equation 1 gives the value of acceptable sample size (N) as 66.25 (~ 67), which is far less than the sample size used in this research (= 87).

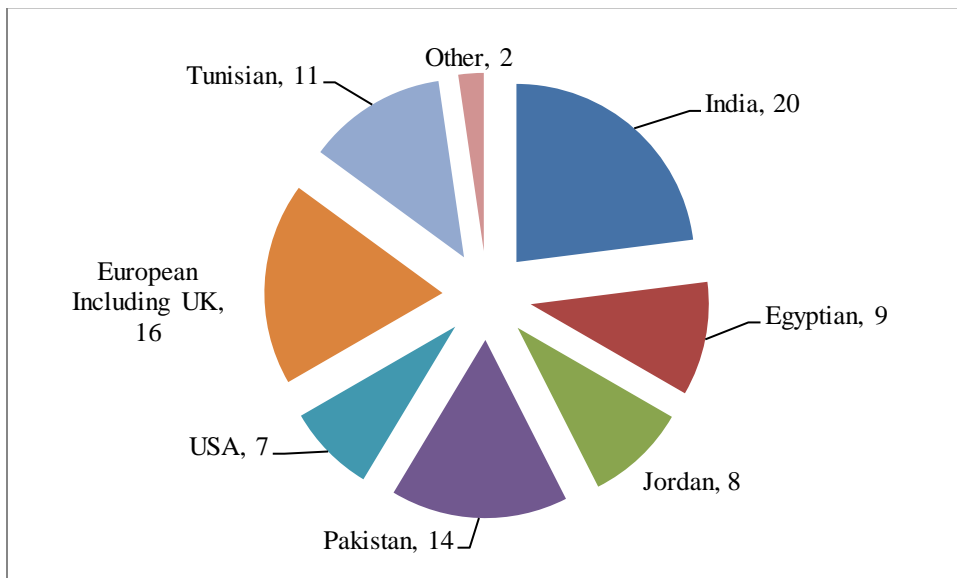
The ratio between skewness and its standards error for age was 0.59. Similarly, the ratio between kurtosis and its standard error for age was 1.24. Both the ratios were found to be less than +1.96, and reflect the normality of data. The correlation between age and qualification of the respondents was found to be significant at the 0.05 level (2 tailed). The internal reliability of all the Likert items along with qualification, position, and country of respondents was checked by calculating Cronbach's Alpha ( $\alpha$ ) using SPSS and was found to be 0.630.

The majority of the respondents participated in the study were from the private University in different GCC countries. This is due to the fact that most of the Universities in the GCC region are private sector Universities. For instance in Oman, there is a total of 34 colleges and universities in which 27 (79.41%) are private institutions. Among seven government higher education institutions, there is only one university and remaining are the colleges (MOHE, 2019). All of the respondents from Oman who participated in the study were from private higher education institutions (figure 6). As discussed in section 4, the participation in the study was on a volunteer basis and the respondents were assured that the data will be treated anonymously; still, the government's influence on their response could not be ignored. However, since these respondents were working in the private higher education institution, it is therefore anticipated that their

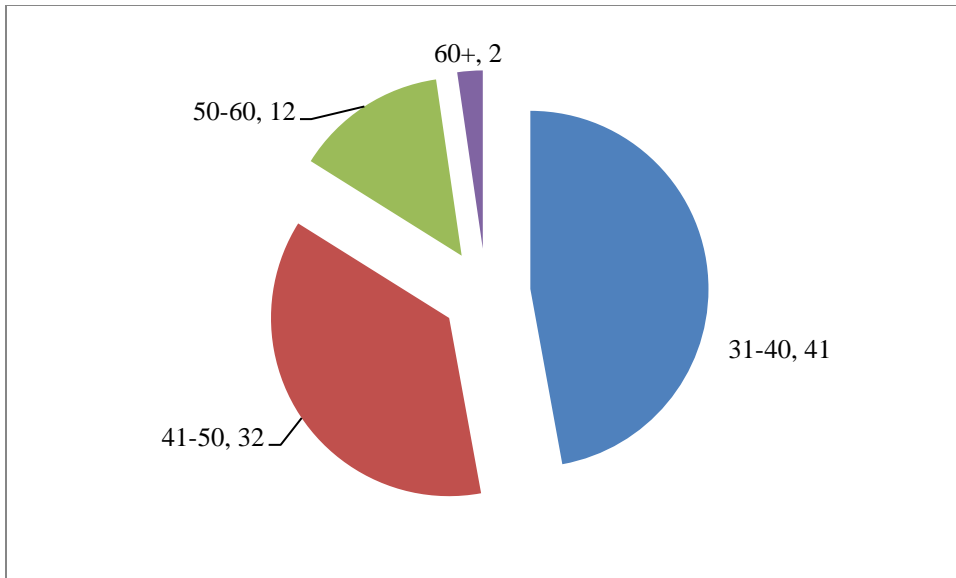
response could not be least affected by any influence if exist. Another factor that increases the reliability of the collected data is that all the respondents were actually from different countries (figure 7). They were just in the GCC region for their job. The response of such respondents is likely to be least affected by any local influence if exist.



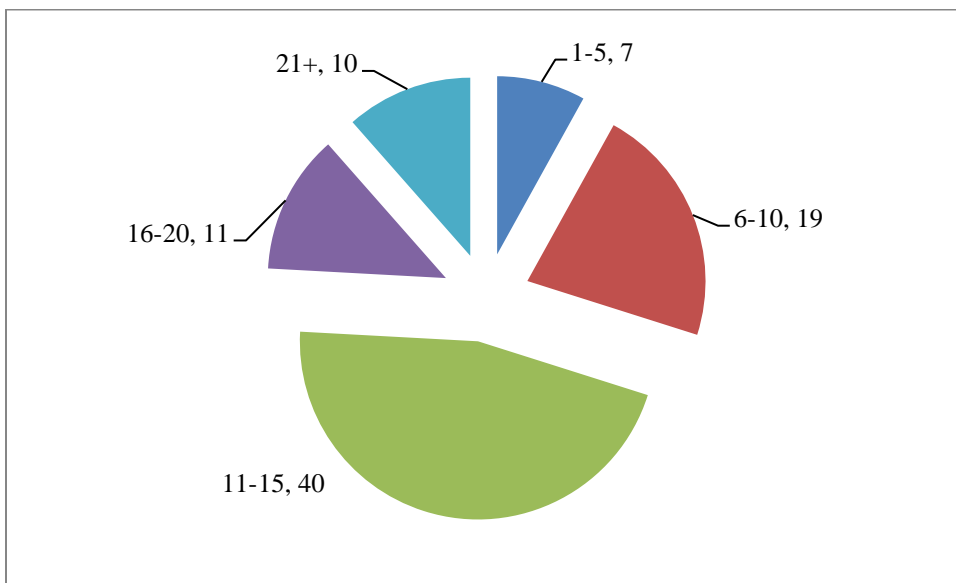
**Figure 6: Participants from Different GCC Countries**



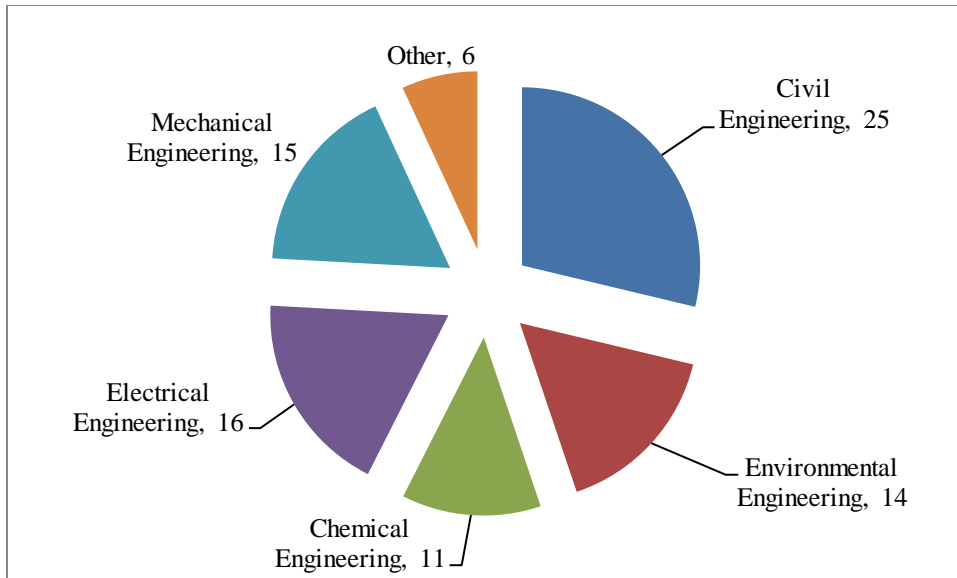
**Figure 7: Demography of Respondents**



**Figure 8: Age Groups of Respondents**



**Figure 9: Experience of Respondents**



**Figure 10: Specialization of Respondents**

The mean values of each element which respondents rated on a Likert scale of 1 to 5 are given in table 2. The mean score of the element “Government Commitment” was 4.02, which means the respondents considered that government commitment is not a challenge in relation to renewable energy. In other words, respondents were agreed that the government is displaying their commitment to renewable energy. Surprisingly, the mean score of “Policies and Regulations” was only 2.07, and thus this element was ranked first. This somehow reflects that although there is a commitment towards renewable energy at the government level, however, at a lower level, this commitment is not well reflected in policies and regulations. Governments of GCC countries will need to develop strategies so that the commitment can easily evident in the policies and regulations developed by different government entities. Similarly, respondents considered “Renewable Energy Education” as a third priority and the main challenge towards renewable energy in the GCC region. The mean score of this element was 2.98. There has been some positive development in relation to renewable energy education in GCC countries, wherein in some universities renewable education has become part of the curriculum and creation of renewable energy centers in some universities. For instance, in A’Sharqiyah University in Oman, renewable energy course with three credits has become a major course in the revised curriculum of Environmental Engineering. Similarly, Heriot-Watt University in Dubai offers an MSc program in Renewable Energy. The

establishment of King Abdullah City for Atomic & Renewable Energy in 2010 in Saudi Arabia reflects some positive moves towards renewable energy education, however, they're still more work required in this area to overcome this challenge. The mean score of "Public Awareness" was 3.15 and therefore this element was ranked as fourth. This reflects that there is awareness among the general public regarding the importance of renewable energy, however, this could be further improved. Of course, renewable energy is important, but to save energy, the change in consumer behavior is important as well. A recent study in Qatar indicates that Qatari citizens are not inclined to modify their energy consumption behavior through economic means due to the presence of energy subsidies (Al-Marri et al., 2018). It is not only to move towards renewable energy but also to save energy through changing behavior and for that education and awareness are compulsory. In the United States and Europe, where energy consumption has been declining since the 1970s due to public information and campaigns for renewable energy and energy conservation (Gellings et al., 2006). Similarly, a report issued by the Department for Business, Energy and Industrial Strategy in the United Kingdom shows a decline in energy consumption from 2005 to 2016 (Waters, 2018). It is also necessary to develop strategies that create awareness among citizens of GCC countries on energy conservation.

The mean score of the next element "Costs and Incentive for Renewable Energy" was ranked as fifth with a mean score of 3.68. This is aligned with the overall situation of the region as there are no taxes and most of the items are subsidies by the government. However, some comments which were provided in the last section of the questionnaire reflect that the respondents are in the view that the subsidy on the electricity bill may be removed so that people can move faster towards solar energy. Two respondents commented that items required for individual houses need to extensively subsidies. Overall, the subsidy from the government on solar items could be helpful, however, at the same time, the building regulations need to be reviewed so that solar installation permission can be granted for both existing and new houses. This process needs to be hazard-free and smooth without any cost or fee.

Element	N	Minimum	Maximum	Mean	Std. Deviation	Rank
Government Commitment	87	1	5	4.02	0.94	VI
Policies and Regulations	87	1	5	2.07	0.89	I
Costs and Incentive for Renewable Energy	87	1	5	3.68	0.83	V
Public Awareness	87	1	5	3.15	0.8	IV
Manpower Experience and Competencies	87	1	5	2.57	0.97	II
Renewable Energy Education	87	1	5	2.98	0.82	III

**Table 2: Ranking of Different Elements (Challenges)**

The next section provides a conclusion of the paper.

## 6. Conclusion:

Global warming and climate change are some of the key challenges to our modern life which need to be tackled properly. In this regard, it is important that the earth resources are to be utilized in a sustainable way so that it could last for long which is important for the human generation and civilization. The main cause of global warming and climate change is the extensive use of fossil fuels which produce greenhouse gases and thus affect the earth's temperature. Another problem with these fossil fuels is that they are non-sustainable, and thus cannot be re-used or used forever. This fact is well recognized around the world and thus efforts are underway to move from these nonrenewable sources to renewable sources such as solar, wind, geothermal, biomass wave and tidal energy. Some countries have not only displayed significant progress in this regard but also have developed innovative solutions that help to reduce energy consumption. This move is, however, not simple and straight forward due to certain challenges and obstacles. This work presented in this article provides an overview of the global energy in general and the GCC region in particular. The GCC region is rich in oil and gas reserves thus recognized as the main energy producer, however at the same time the region consumed a huge quantity of energy. Although the GCC region has a hot and humid climate, however, the energy consumption per capita (=12,896.058 kWh) is more than double the consumption in China and the United Kingdom. Similarly, the CO<sub>2</sub> emission in the region is equal to 25.36 Metric Ton, three times greater than the CO<sub>2</sub> emission per capita in China and four times



greater than the CO<sub>2</sub> emission per capita in the United Kingdom. The main reason for the high consumption and emission discussed in this paper are the low costs of energy and the extensive use of fossil fuels in industries including electricity production. The region's progress towards renewable energy is comparatively slow if compared with other regions. Many research studies have demonstrated that much of the renewable energy resources (solar, wind, geothermal, hydropower, biomass, wave and tidal) have enough potential and can be utilized at the individual or commercial levels. The main challenges identified in this research which affecting the region progress towards renewable energy are (i) Policies and Regulations, (ii) Manpower Experience and Competencies (iii) Renewable Energy Education (iv) Public Awareness (v) Costs and Incentive for Renewable Energy (vi) Government Commitment. It is anticipated that the findings of this research could be helpful to government organizations' decision-makers to understand the obstacles which affect their progress towards renewable energy. The findings of this research will help the decision-makers develop effective strategies to excel their progress on renewable energy. The results presented in this paper are based on the data collected from a specific group (university lecturers and professors), thus present the view of a specific group based on their understanding. Time and resources did not permit to involve other participants particularly from the industry and other government organizations. With this limitation, the results of this research help to understand the main challenges of the region in renewable energy and open the door for further research. For instance, one of the main challenges which are ranked as third, is "Renewable Energy Education", thus further research can be conducted in this area to understand that what is the current level of the renewable energy education in the region and what level could be required which could accelerate the region progress in renewable energy.

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