

Conventional, Wind and Solar Energy Resources in Oman

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Abstract:

Energy has become an important sector in the strategy termed: Omani vision 2020. Renewable energy sources can form a vital and strategic solution for the provision of electric power in the Sultanate. This paper provides a comprehensive review of Oman conventional and renewable energy resources (wind and solar). Although Oman is not currently utilizing its renewable energy resources, this study reveals that renewable energy resources such as wind and solar are have enough potential which can be directly utilized for electricity generation.

Key Words: Renewable Energy, Energy Conservation, Fossil fuels, Natural Resources

1. Introduction:

Energy is essential to economic and social development and improved quality of life in all countries. Much of the world's energy however is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially. The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption.

Climate change is one of the most difficult challenges facing the world today and preventing will necessitate profound changes in the way we produce, distribute and consume energy. Burning fossil fuels such as coal, oil and gas provides about three quarters of the world's energy. However, when these same fuels are burned, they emit greenhouse gases that are now recognized

as being responsible for climate change (IEA, 2002; Lee R, 2002; Wolfson R, and Schneider SH, 2002).

Oman, like other Arab gulf countries, depends on oil and gas to produce electricity. However, these resources are not guaranteed to last forever, and are one of the energy security issues in the country. Some of the gulf countries have diversified their energy resources for example, the Emirates has considered nuclear and renewable energy as part of their electric generation and Qatar aims to generate 20% of its energy from renewables by 2024 with 1800MW of installed green capacity by 2020. As for Oman, the progress of renewable energy development is at a slow pace as currently the electricity generation is still dependant on oil and gas. Omani Vision 2020 seeks to reduce dependence on oil, diversify the economy and create new employment opportunities for all citizens. Omani Vision 2020 also stresses on the promotion of technology transfer and the increased use of natural and renewable resources, with due regard to the social and natural environment, which gives priority to the main key aspects (NCSI, 2008).

1.1. Electricity Consumption in GCC Regions:

In the last two decades energy consumption in the GCC has increased rapidly. In 2013, the average electricity consumption in Gulf Cooperation Council (GCC) countries was approximately 12370.91 kWh per year per capita while in China this value was 3762.07 (World Bank 2016). GCC countries electricity consumption is more than double of the consumption per capita in United Kingdom, which is 5407.29 kWh. GCC countries' electricity consumption is driven largely by home use, with almost 47% of the energy consumption siphoned into residential use as compared to a global average of around 25% Deloitte (2008). World Bank data

on electricity consumption per capita for the last ten years (2004 – 2013) reveals an average increase in consumption of 1.23 % per year (World Bank 2016). This data further reveals that Bahrain is having highest consumption rate of electricity in 2013, follow by Qatar, Kuwait, United Arab Emirates, Saudi Arabia and then Oman (Figure 1). Electricity consumption in Oman and Saudi Arabia significantly increased by 5.6% and 4.3% per year respectively as shown in figure 2, while consumption in other GCC countries reduced by a small percentage. Considering the World Bank data on electricity consumption per capita, in United States and United Kingdom the consumption is reduced by 3 % and 1.2 % respectively in the same period (2004-2013).

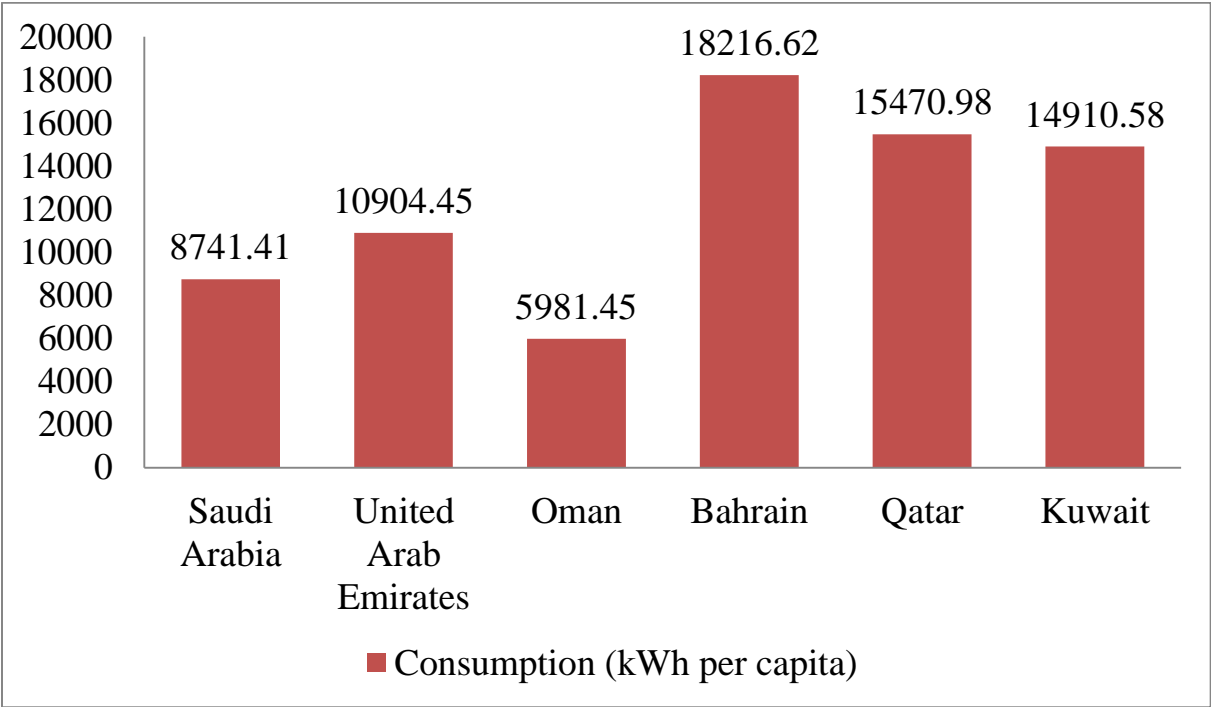


Figure 1. Electric Power Consumption in GCC Countries (2013) - (World Bank 2016)

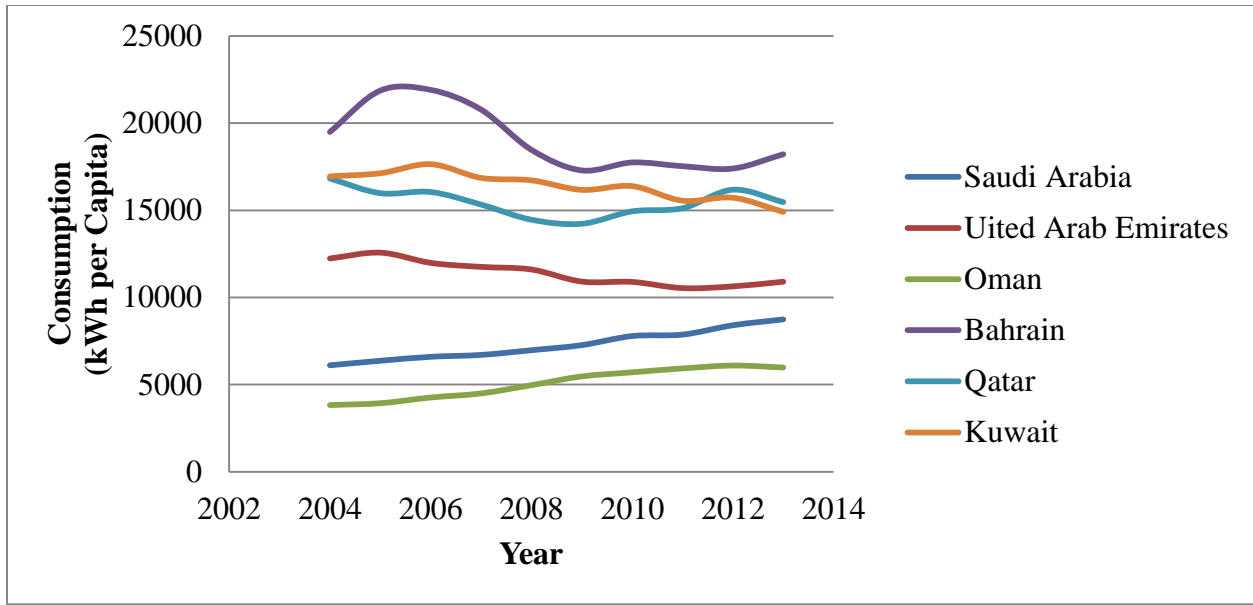


Figure 2. Electric Power Consumption (kWh per Capita) in Different GCC Countries from 2004 - 2013, (World Bank 2016)

2. Background of Oman Conventional Energy

Oman's economy is heavily reliant on oil and gas revenues, which accounted for about 84% in 2014 of the country's export earnings and 47.2% of its gross domestic product (CBO, 2015, NCSI, 2015). All of Oman's domestic energy consumption is supplied by natural gas and oil, reflecting the country's relative abundance of oil and natural gas reserves. In 2011, oil accounted for 71% of Oman's total primary energy consumption, and natural gas made up the remaining 29%. With the exception of 2009, Oman's petroleum consumption rose steadily over the past decade, reaching 154,000 barrels/day in 2013. This further has a significant contribution towards greenhouses gases.

2.1 Oil and Gas Reserves in Oman:

A report published in Oil & Gas Journal, shows that Oman has 5.5 billion barrels of estimated proved oil reserves as of January 2014 (Oil & Gas Journal, 2014). Oman's 5.5 billion barrels of proved oil reserves rank 7th in the Middle East and 23rd in the world. A report published by the U.S. Geological Survey in 2012 stated that the estimated mean undiscovered energy resources in the South Oman Salt Basin located in the southern part of the country are more than 370 million barrels of oil, 315 billion cubic feet of natural gas, and more than 40 million barrels of natural gas liquids (U.S. Geological Survey, 2012). The current oil and gas reserves in Oman are shown in Figure 3 and 4 (EIA, 2015).

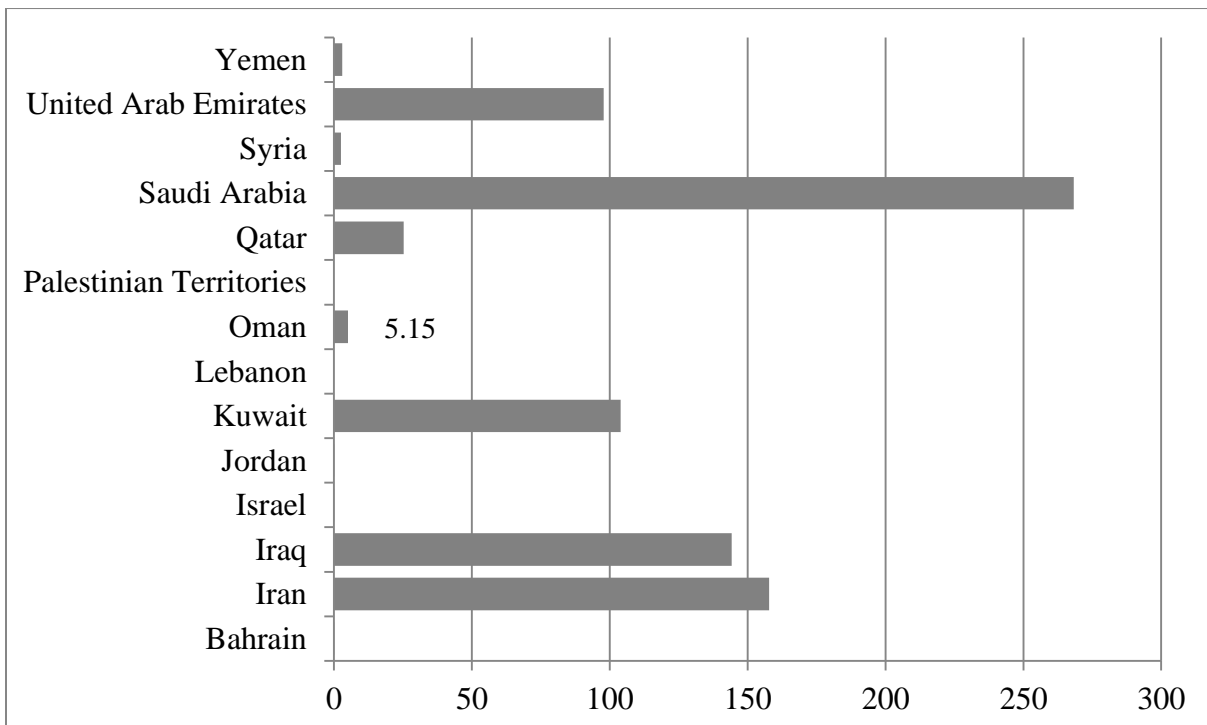


Figure 3. Selected Middle East Proven Oil Reserves in Billion Barrels, 2015. (EIA, 2015)

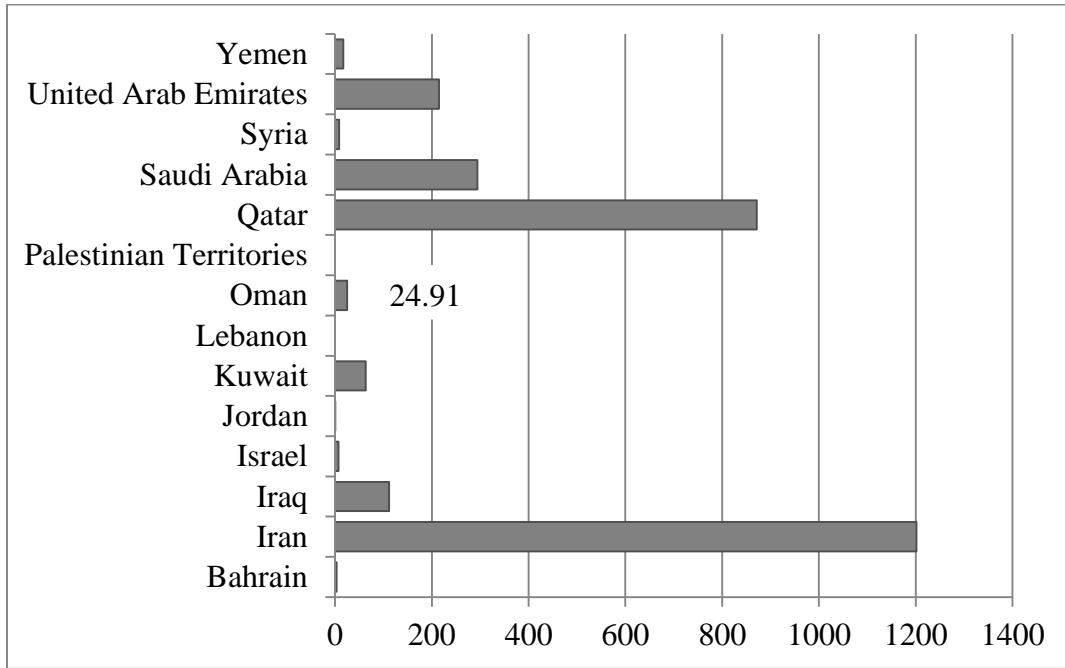


Figure 4. Selected Middle East Proven Natural Gas Reserves in Trillion Cubic Feet, 2015
(EIA, 2015)

3. Renewable energy resources in Oman

In 2008, the Oman Authority of Electricity Regulation did a study on the renewable resources in Oman. The study finds significant potential sources of renewable energy in the Sultanate of Oman which covers wind energy, solar energy, biogas, wave energy and geothermal energy. In this article the wind and solar energy resources are discussed in detail.

3.1 Wind energy

The assessment of the wind energy resources in this article is based on the wind data measured at twenty one stations in Oman under the responsibility of Directorate General of Civil Aviation

and Meteorology. The Directorate General of Civil Aviation and Meteorology measured the wind speed at a height of 10 meter above ground level. Five stations named as Qairoon Hariti, Thumrait, Masirah, Joba and Sur having high wind speed were selected to determine the wind energy content. The wind speed at 80 meter above ground level were estimated which is equal to the hub height of a modern large wind turbine, having a capacity in the order of 2-3 MW. The procedure of Danish Wind Industry Association (www.windpower.org) is used for calculation of wind speed at 80 meter height. The measured annual mean wind speed at 10 m and the estimated annual mean wind speed at 80 m above ground level at each of the five selected metrological station is shown in Figure 5.

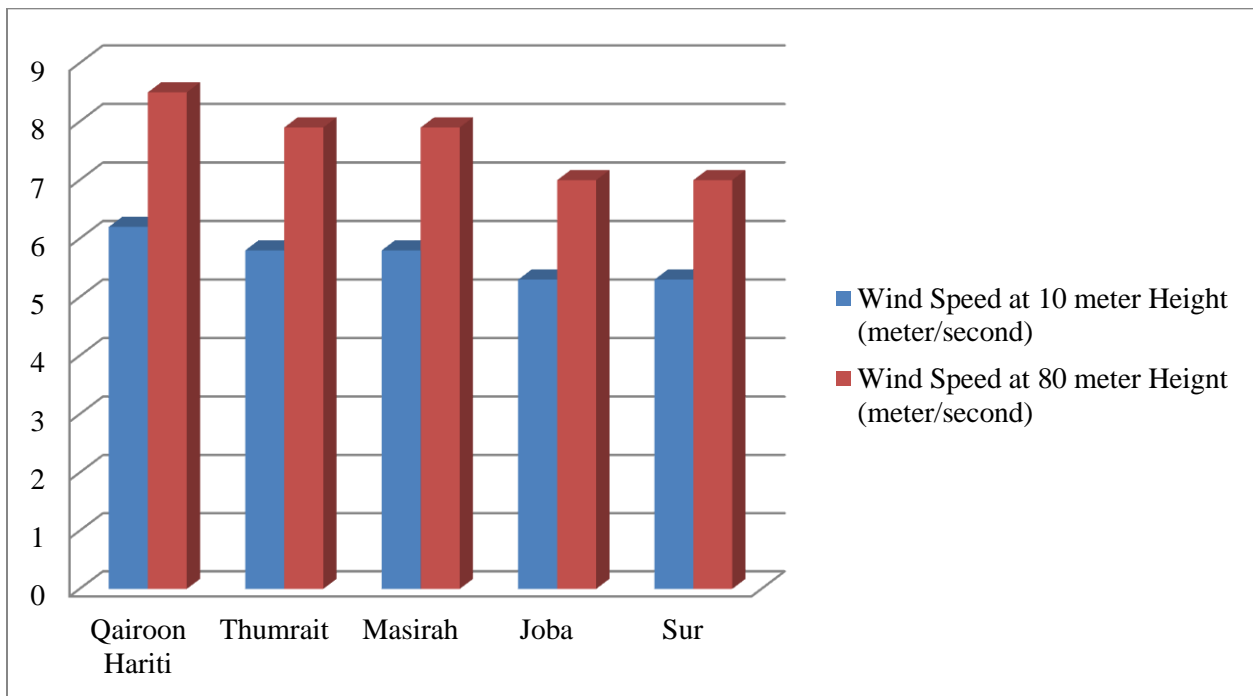


Figure 5. Annual mean wind speed at 10 m and at 80 m above ground level at five meteorological stations.

The annual wind energy content at each five station is roughly estimated as per Danish Wind Industry Association (www.windpower.org) and the results are presented in figure 6. The energy is specified as kilowatt hour (kWh) per year through a vertical area of one meter square (m²).

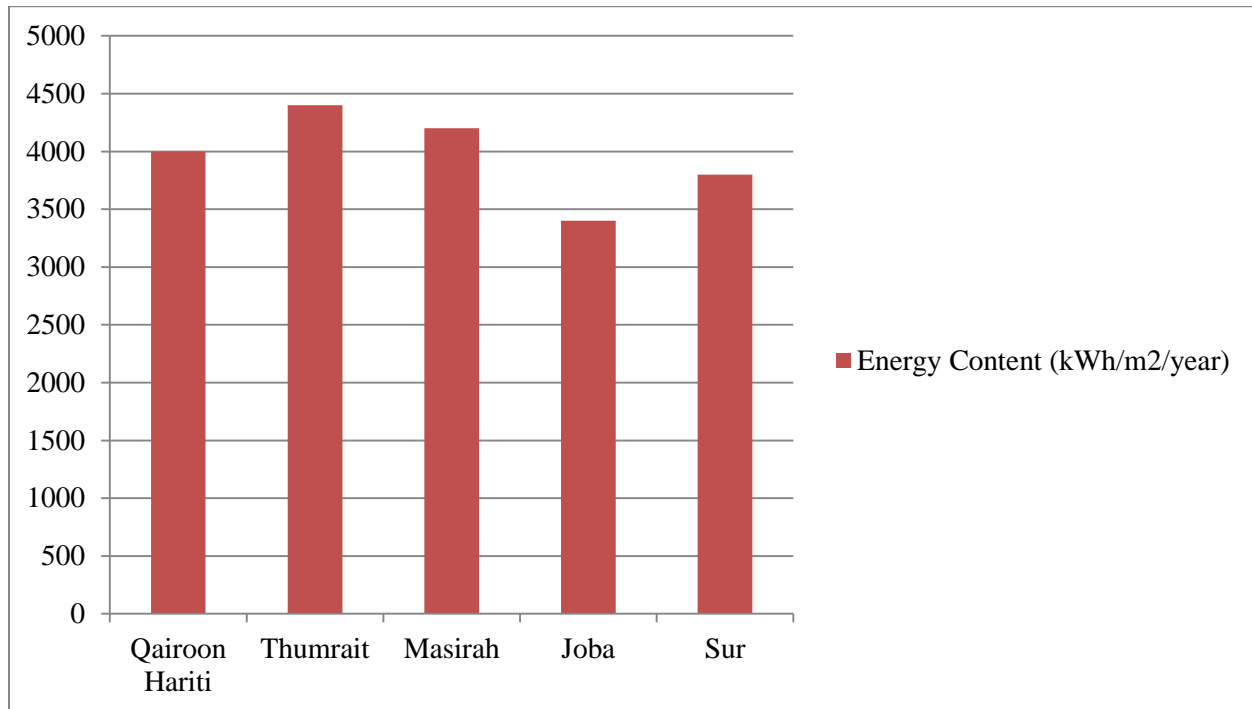


Figure 6. Energy content in the wind at 80 m above ground level at five meteorological stations.

3.2 Solar energy

The solar insolation varies from year to year. It is therefore important to use data covering several years in order to estimate the long term average solar energy resources. In this article the solar data is obtained from the study conducted by Authority of Electricity Regulation, Oman (AER, 2008). This data was collected from 1987 to 1992 at six different locations in Oman. The general formula (given below) which is commonly used to calculate the solar energy output is

applied to this data to estimate the energy content at selected locations. The results of solar energy content at different locations are shown in figure 7. The energy is specified as kilowatt hour (kWh) per year through a vertical area of one meter square (m²).

$$E = A \times r \times H \times PR$$

Where;

E = Energy (kWh)

A = Total solar panel Area (m²)

r = solar panel yield (%)

H = Annual average solar radiation on tilted panels (shadings not included)

PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)

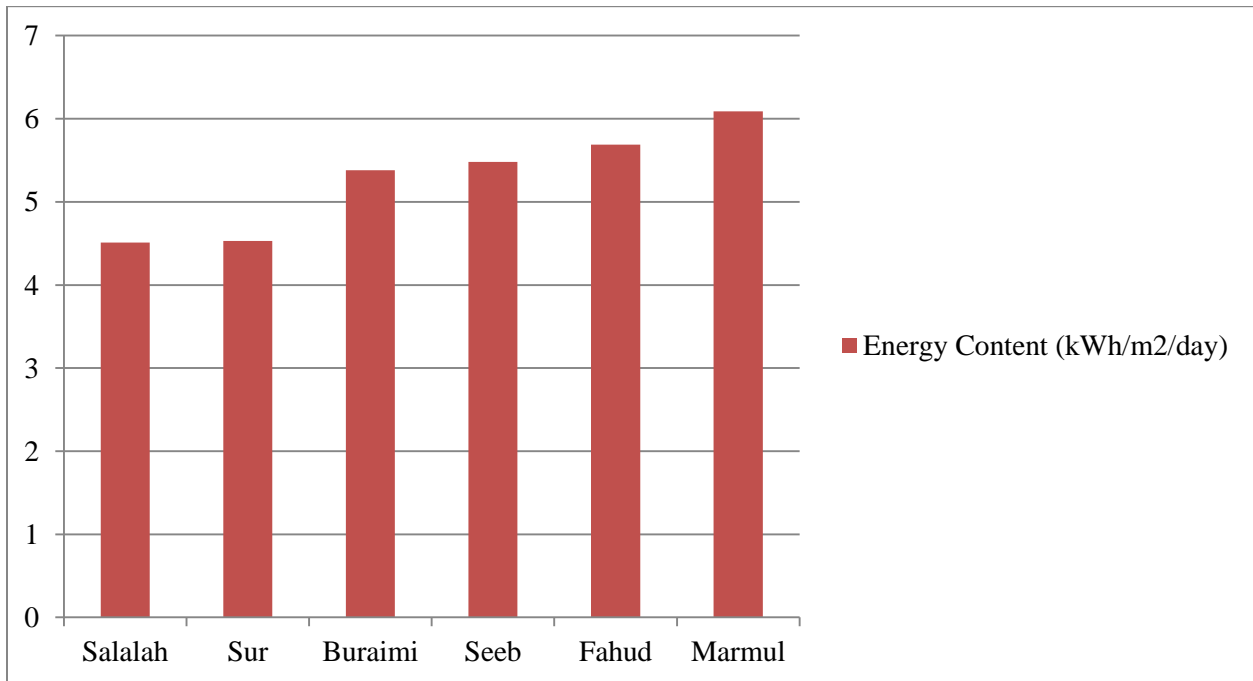


Figure 7. Solar Energy Content at Six different Locations in Oman.

Although there is a rich solar potential in Oman, however dust and sandstorm are some of the factors that can reduce the efficiency and output of solar PV (photovoltaic) installation. Solar panels' efficiencies can decrease during sandstorms, and some of these decreases are permanent when the protective glass sheets are damaged by erosion (N. Bouaouadja et al. 2010). Research conducted by Mani and Pillai (2010) described different conditions influencing PV performance and dust deposition and recommended cleaning cycle to mitigate impact of dust. Further research need to be conducted to fully understand the issues of solar energy storage and distribution considering the local electricity demand and location. Research conducted in UK by Alexander and James (2015) considered the impact of distributed energy storage in the form of heat pumps and electric vehicles which can help to balance a 100% renewable UK electricity grid. Chia Ai Ooi et al. (2015) considered the use of in grid-scale battery energy storage systems (BESSs) by integration of a full-bridge modular multi-level converter and a large number of lithium-ion cells interfacing with an AC electrical grid.

4. Conclusion

There is a great opportunity for Oman to utilize renewable energy for commercial advantage, as solar and wind energy in particular can achieve more competitive costs. The effective use of these energy resources would require the development of a suitable skills base and provide the opportunity to develop a local level of manufacturing, each involving an increase in the level of skilled employment. It would contribute to the extension and diversification of both the economy and energy sources. It would be in line with the objectives of Oman Vision 2020. It would also help Oman establish a world position in this energy sector by providing a professional

demonstration and monitoring capability for technology providers, as well as helping to carry forward the development of relevant technologies. Dust and sandstorm are the possible factors which will be affecting the efficiencies and output of solar PV. The issues of storage and distribution are some of the challenges which need to be addressed with suitable solutions to use the wind and solar energy effectively in Oman.

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