



Potential and readiness analysis of renewable energy in the GCC states

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Abstract

The paper aims at better understanding of the opportunities and potentials of the deployment of clean energy in the region of highest fossil fuel reserves in the world, the gulf cooperation council (GCC) states, by conducting a comprehensive analysis of the seventh sustainable development goal (SDG7) in the GCC states context including a detailed description of its targets, indicators as well as interrelatedness with the other SDGs. In line with that, the paper evaluated the renewable energy potential in the GCC states, its readiness to deploy and the constrains still to overcome. Analysis showed that GCC region has got a high potential of solar and wind energy, and good readiness for its deployment. The potential of solar energy resources in GCC states varies between 5.1 to 5.9 kWh/m² year. The average wind speed in GCC countries is between 3.5 -6 m/s, with the highest average of 6 m/s in Qatar and lowest average of 3.5 in Saudi Arabia. **Copyright © 2020 International Energy and Environment Foundation - All rights reserved.**

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1. Introduction

Energy is defined as the ability to do work. It can be found in different forms such as chemical, electrical, mechanical, thermal, nuclear and gravitational.

In general, energy can be obtained from fossil fuel, renewable or nuclear sources as explained in Figure 1. These sources can be categorized in two main types, renewable sources including the solar, wind, hydro and geothermal; and non-renewable sources such as fossil fuel including coal, oil and gas as explained in Figure1. However the categorization of nuclear energy in the renewable energy list is a subject of major debate for two big arguments, the first one is the fact that unlike solar and wind are infinite sources, uranium is a limited source and the second is the harmful nature of its waste characterized as a radioactive pollutant, which goes against the notion of renewable energy source [1-5].

One of the grand challenges that face the world today is to meet the growing energy demands and ensure affordable, reliable, sustainable and modern energy in a sustainable manner for all people. However, the current situation indicates that energy is still a global grand challenge to address because of the following main facts:

1. 20% of the world population lacks access to modern electricity (pwc, 2019),
2. More than third of the world population still use kerosene, wood, coal or even dung for cooking and heating (Navid, 2012).

3. The least likely to access a source of power are the poorest, which makes them more likely to remain poor (Sri, 2015).
4. Currently about 66% of all greenhouse gases GHGs emissions is caused by the production and use of energy causing the climate change and global warming (The Synthesis Report, 2013& International Energy Agency, 2014).
5. The global per capita electricity consumption has been doubled since 1970 and is expected to rise by 20-35% by 2030. (The Synthesis Report, 2013).

This paper will be analyzing the SDG7 in the context of the current situation of the GCC states and the progress achieved in deploying clean energy.

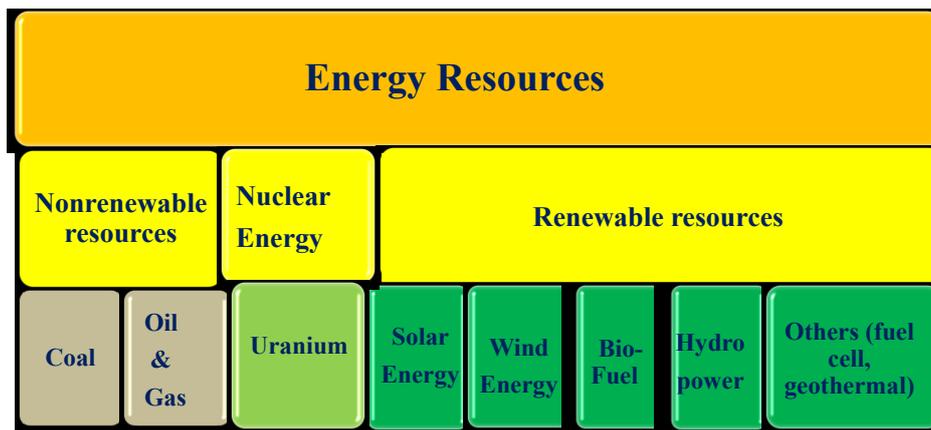


Figure 1. Different energy resources.

2. Clean Energy

There are several definitions of clean energy; the environmental protection agency EPA defines clean energy as any resource that satisfies the demand of energy but with less pollution than the traditional resource of fossil fuel including coal, oil and gas. Based on this definition, clean energy resources include: (1) energy efficiency as it achieves the same or higher level of services but with less energy consumptions, (2) renewable energy which refers to infinite source of energy including wind, solar, hydro, bio-fuel, geothermal and fuel cells. (3) combined heat and power (CHP) whose principle is the recovery of wasted heat from electricity generation for the production of thermal energy and (4) clean distributed generation (DG) which refers to electrical generation and storage by small scale renewable energy and CHP distributed system-connected devices that allows you to power your home or business at the end-use site and any surplus produced electricity can be fed into the grid [6, 7].

Clean energy systems can offer many benefits such as environmental, social and economic including reduced emissions, lower requirement for energy input, increase system efficiencies by expanding useful outputs,

2.1 Clean energy in SDGs

The Sustainable Development Goals (SDGs) is a universal call of multiple focus targets including ending the poverty of people, protecting the planet, ensuring that all people enjoy peace, strengthening partnership to achieve prosperity for all. It is a universal call that aims at achieving three ultimate goals; these are ending poverty, protecting the planet and ensuring that all people enjoy peace and prosperity by 2030. It consists of 17 global goals designed to be a "blueprint to achieve a better and more sustainable future for all". Each of the 17 sustainable development goals has a list of targets (the total is 169 targets) which are measured with indicators.

Each goal contains two types of targets, Outcome targets defined as "the circumstances to be attained", and the Means of Implementation (MoI) targets, defined by the UN as "the interdependent mix of financial resources, technology development and transfer, capacity-building, inclusive and equitable globalisation and trade, regional integration, as well as the creation of a national enabling environment required to implement the new sustainable development agenda".

The seventh sustainable development goal (SDG 7) aims at achieving affordable, reliable, sustainable and modern energy for all people (Figure 2).



Figure 2. The 17th Sustainable Development Goals (SDGs).

2.2. Targets of SDG 7

This sustainable development goal (SDG7) includes three outcomes targets (7.1-7.3) and 2 means of implementation targets (MoI) (7.a and 7.b) detailed as follows [8]:

The three outcome targets of this goal are:

- 1) (7.1) “Ensure universal access to affordable, reliable and modern energy service by 2030”.
- 2) (7.2) “Increase substantially the share of renewable energy in the global energy mix by 2030”.
- 3) (7.3) “Double the global rate of improvement in energy efficiency by 2030”.

The two means of implementations targets are:

(7.a) “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”.

(7.b) “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 programmes of support” [8].

2.2.1 Indicators

Indicators are designed to measure the progress achieved in meeting the targets of SDGs. For the SDG 7, the following indicators are used [9]:

For the above outcome target (7.1) about access to affordable, reliable and modern energy it is measured by two indicators:

- (1) 7.1.1 “The proportion of population with access to electricity. This is measured as the share of people with electricity access at the household level. It comprises electricity sold commercially, both on-grid and off-grid” and
- (2) 7.1.2 “The proportion of population with primary reliance on clean fuels and technology. This is measured as the share of the total population with access to clean fuels and technologies for cooking. Access to clean fuels or technologies such as clean cookstoves which reduces exposure to indoor air pollutants, a leading cause of death in low-income households”.

For the second outcome target (7.2) related to share of renewable energy in the global energy mix, it is measured by one indicator 7.2.1 which reads “The renewable energy share in the total final energy consumption”. This is measured as renewable energy (inclusive of solar, wind, geothermal, hydropower, bioenergy and marine sources) as a share of final (not primary) energy consumption. Energy mix includes electricity, transportation and cooking/heating fuels.

The third outcome target related to energy efficiency, the following indicator was assigned: Indicator 7.3.1 which reads “Energy intensity measured in terms of primary energy and GDP”. This is measured as the energy intensity of economies (collectively across all sectors). Energy intensity is measured as the quantity of kilowatt-hours produced per 2011 international-\$ of gross domestic product (kWh per 2011 int-\$).

For the means of implementation (MoI), one indicator was assigned for each target. For the target related to international cooperation (7.a), the indicator 7.A.1 was assigned which measures the international financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems. For the second target of MoI related to infrastructure and

technology, the indicator 7.B.1 was assigned to measure the investments in energy efficiency as a proportion of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services.

2.2.2 Interrelatedness with other SDGs

This goal interrelates with other SDGs detailed as follows:

- Goal 1 – “End poverty in all its forms everywhere”: the SDG7 interrelates with SDG1 as securing energy with affordable prices is well aligned in ending poverty by improving the standard of living. Example on that is the Sub-Saharan Africa where according to 2018 reports of International Energy Agency, 600 million people are still without access to electricity.[10]
- Goal 10 – “Reduce inequality within and among countries”: It interconnects with this goal in terms of addressing lack of access to energy by the poorest.
- Goal 12 – “Responsible consumption and production: the need for energy consumption to become more efficient links to the broader need for resource efficiency in consumption and production and to decouple economic growth from environmental degradation”.
- Goal 13 – “Climate action: the challenges of climate and energy are inexorably connected: to address the increase in global temperature, we must de-link energy use from emissions by decarbonizing our power sources, i.e. reducing emissions from energy.

3. Energy profile in the GCC

The GCC stands for Gulf Cooperation Council which is a political and economic union that includes all Arab states in the Gulf except Iraq: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

The GCC region is very rich in fossil fuel resources where it accounts for 30.5% of the world’s proven oil reserves at the end of 2018 as per the BP statistical review of world energy report of 2019. Figure 3 Shows the trend of GCC's % of the world's proven oil reserves since 1998[11].

Also the GCC region accounts for 19.9% of proven natural gas reserves at the end of 2018 [11]. The following Figure 4 shows the trend of GCC's percentage of the proven global natural gas reserves.

This situation of having huge reserves of oil and gas, the rapid population growth, the enhancement of living standards and the high focus on energy-consuming industry led to increase the electricity production from 399 TWh in 2009 to 656.5 TWh in 2019[11] as seen in the Figure 5.

However, due to the fact that fossil fuel is not renewable and that the reserves of oil and gas are finite; at the current production rates it is estimated that the oil reserves will continue for another 70 years and the natural gas for another 118 years [12]. Therefore the GCC states have no other option but to look for alternative and sustainable energy resources.

GCC countries are facing two main challenges, the first is to enhance the future energy security and the second is to reduce the CO₂ emissions. To address these challenges and to achieve a better sustainable development, clean energy was identified by the United Nations as a potential solution. Therefore the seventh sustainable development goal aims at ensuring access to affordable, reliable, sustainable and modern energy for all.

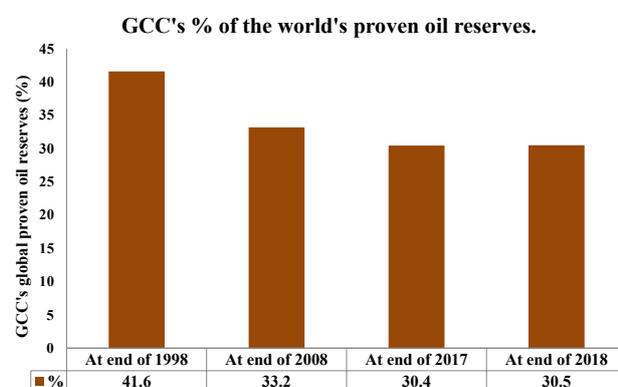


Figure 3. GCC's % of the world's proven oil reserves since 1998.

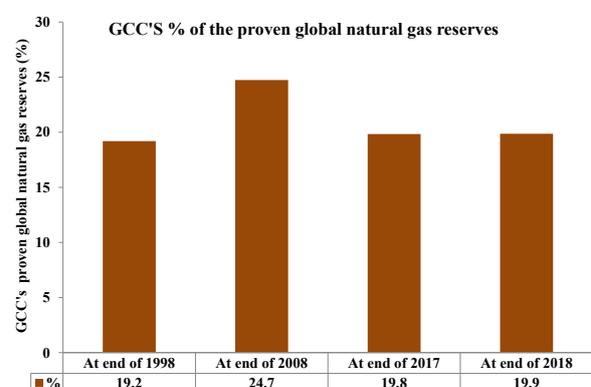


Figure 4. Trend of GCC's percentage of the proven global natural gas reserves.

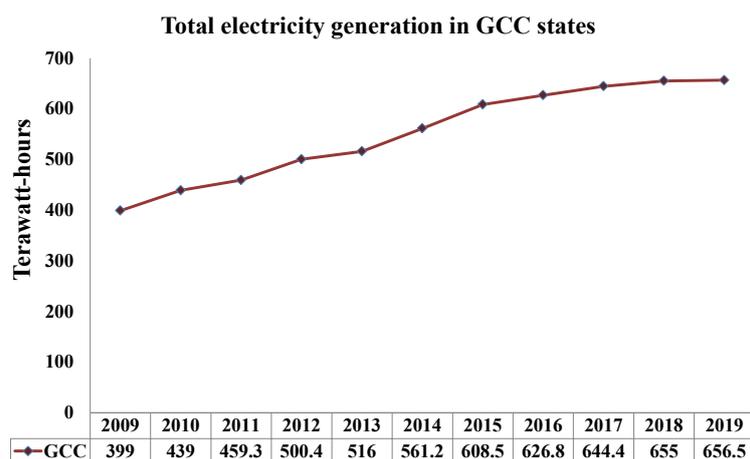


Figure 5. Electricity production in GCC states.

4. Renewable energy

Renewable energy (RE) is energy generated partially or entirely from non-depleting energy sources for direct end use or electricity generation. It includes wind, solar, and geothermal energy. Hydro, biomass, biogas, and waste-to-energy are also renewable energy sources. Renewable energy can be generated on site or at a central station.

There are four main categories of benefits for the deploying of renewable energy in any country including the following [13]:

1. Sustainability: Renewable energies are sustainable source of energy, inexhaustible and naturally replenished. Once constructed and fully operated, they provide permanent and low cost source of energy.
2. Diversification: Renewable energies promote a diverse the portfolio of energy generation which reduces a country dependency of a sole form of technology or fuel.
3. Environmental: Renewable energies have the lowest environmental diverse impacts of all energy sources on the environment. The unwanted by products discharged to air, soil and water are lower than when associated to other sources of energy.
4. Economical: A part of the generated energy, renewable energy generates more jobs and wider range of employment opportunities from high technology of manufacturing PV to maintenance jobs. Renewable energy systems are flexible and can be installed anywhere and in any size.

4.1 Potential of renewable energy in GCC countries

4.1.1 Solar

The application of solar energy can be classified in three categories: electricity production, thermal applications and chemical processes. The most common application is for water heating. Electricity can be produced by either photovoltaic technology or concentrated solar thermal-electric technologies. Over the past years, solar technology witnessed drastic improvements in both increased efficiency and reduced cost. It is estimated that the irradiation of solar energy per square meter per year on the ground is equivalent to 1-2 barrels of fuel oil. The potential for solar energy in GCC states is quite high varying between 5.1 to 5.9 kWh/m² year [14].

Figure 6 shows solar potentials for all GCC states with the highest potential for Saudi Arabia, and Figure 7 illustrates the solar scores for the GCC states.

4.1.2 Wind Energy

Wind energy is attributed to kinetic energy of wind, which can be converted to useful forms of mechanical or electrical energy. The amount of kinetic energy presents in the wind is a function of wind speed and is affected by air density. The optimum output is obtained from the windiest areas where the wind speed increases with the height above the ground. According to the UN reports the total potential for wind energy alone can meet the electricity world demand by several times.

The energy obtained from wind is considered an ideal renewable source of energy because it is considered a pollution free source, sustainable, infinite, the process of generation does not require fuel and therefore no greenhouse gasses emissions, and the process does not produce toxic or radioactive waste.

It has been stated that each megawatt-hour of electricity that is generated by wind energy offsets about 0.8-0.9 tons of greenhouse gas emissions generated each year that are produced by fossil fuel sources [14]. Also wind energy is considered the least expensive renewable source of energy and its production cost has improved so dramatically over the years. As wind energy is positively correlated to wind speed, the higher the wind speed is, the more electricity will be generated per wind turbine, and hence the cost of energy per kWh will be lower [13].

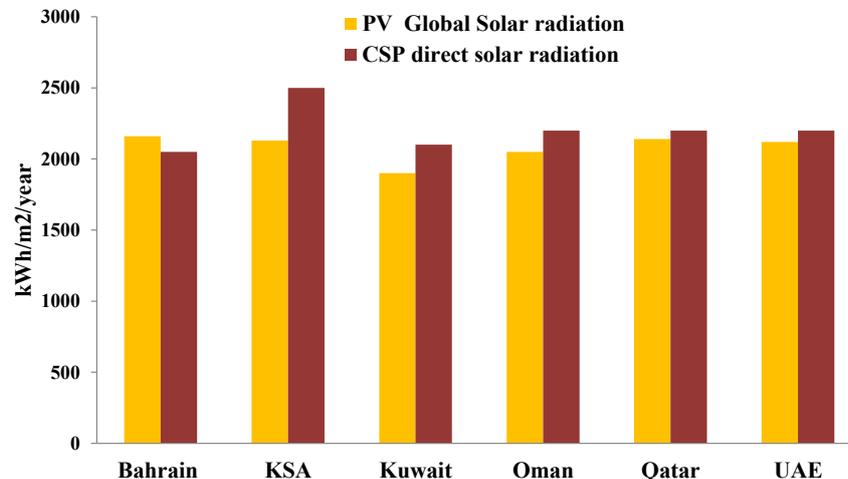


Figure 6. Solar energy potential of GCC states.

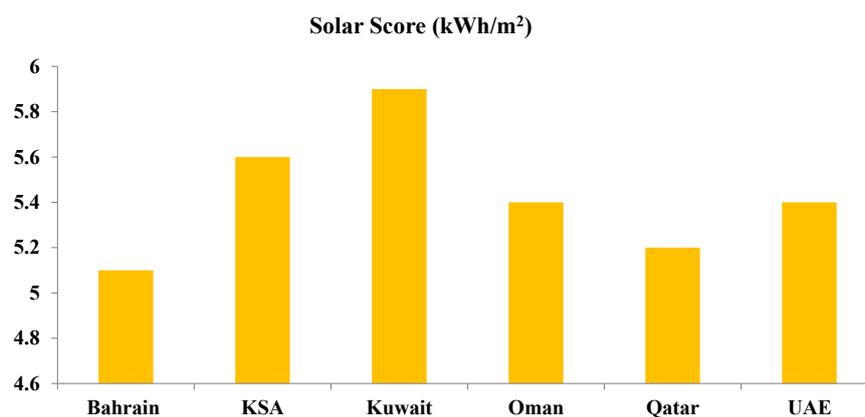


Figure 7. Comparative score of solar energy of different GCC states.

There size categories of wind turbines were reported:

1. “Grid-connected large turbines (1.5 MW-2 MW per turbine)”
2. “Medium size turbine (25 kW-150 kW) typically used in hybrid systems. Typical application is for water pumping for remote areas used for agriculture and farming activities.”
3. “Small wind turbines (less than 25 kW) used in remote, standalone applications.”

While the GCC countries have substantial solar energy, they have moderate wind energy potential. The average wind speed in GCC countries is between 3.5 -6 m/s, with the highest average of 6 m/s in Qatar and lowest average of 3.5 in Saudi Arabia as seen in Figure 8 [14]. The comparison scores of the GCC states are seen in Figure 9.

4.2 Renewable Energy –Readiness analysis

In a conducted study in 2016 about the renewable energy readiness in the GCC countries, the three main pillars of infrastructure, institutions and human capital were analyzed for each country identifying the strengths and gaps for the development of renewable energy in the GCC countries and its readiness for its deployment, each pillar was given a score between 1 and 7 with 1 being the lowest and 7 the highest. The obtained results, shown in Figure10, revealed that while the existing infrastructure was relatively strong, the human capital was relatively low [14].

Based on the scores of the three pillars for each country and giving a weight of 33% for each one, the study calculated the index of renewable energy readiness (RE-Readiness) for each country of the GCC with highest score of 4.75 out of 7 for United Arab Emirates and lowest of 3.8 for Kuwait due to lack of market infrastructure. As illustrated in Figure 11.

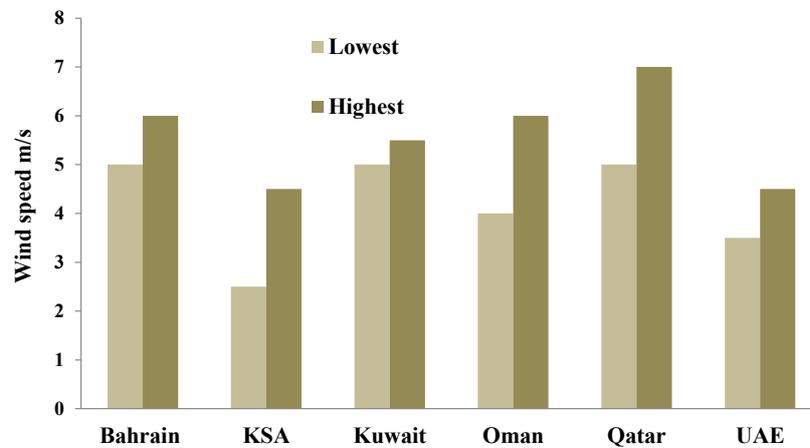


Figure 8. Highest and lowest wind speed in GCC countries.

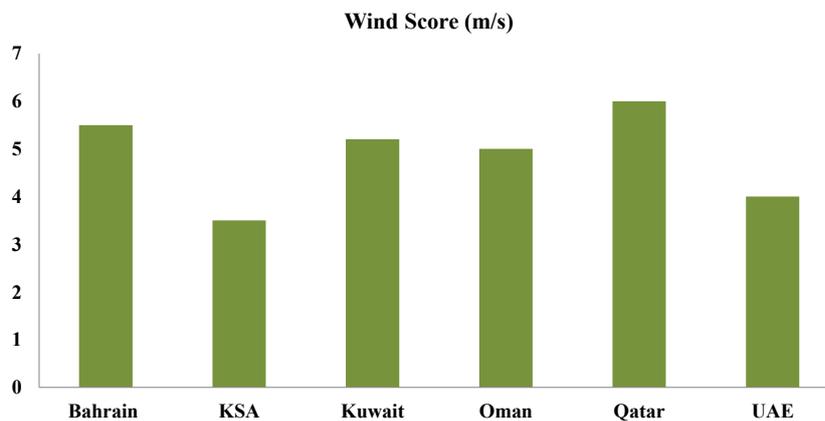


Figure 9. Comparison of wind energy score of GCC countries.

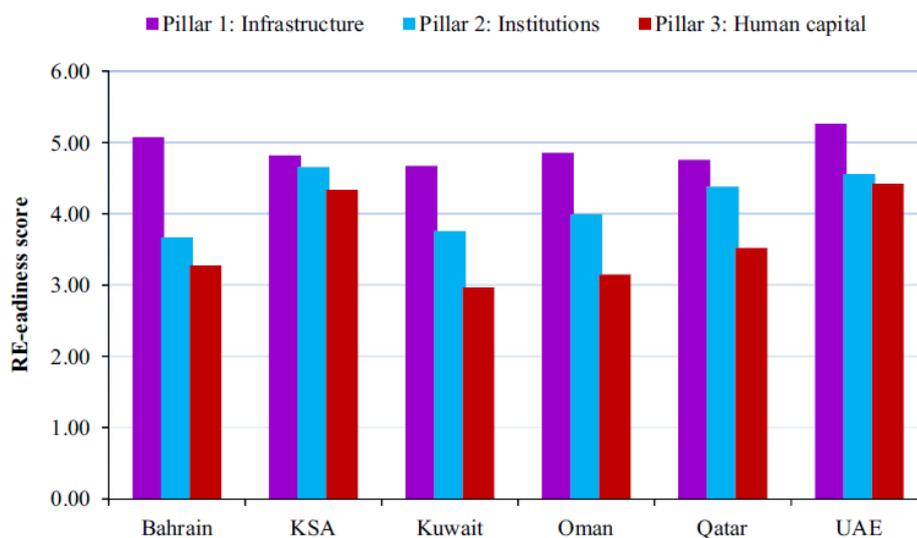


Figure 10. The GCC countries' attractiveness index on renewable energy development pillars.

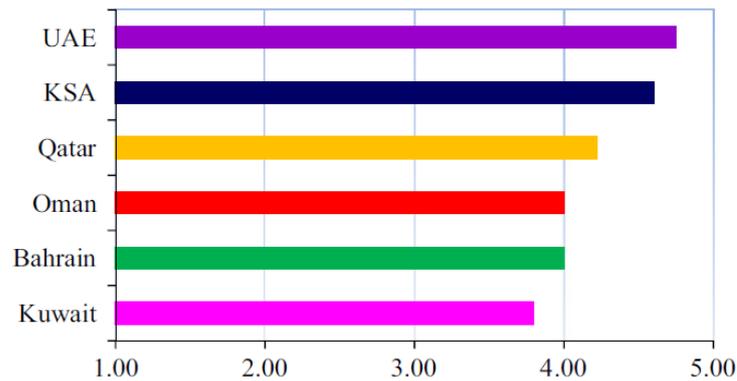


Figure 11. The GCC countries RE-readiness index.

5. Conclusions

- The analysis of current and future options in the GCC states showed that GCC region has got a high potential of solar and wind energy, and good readiness for its deployment.
- Also the deployment of clean energy is considered a mitigation measure to alleviate the climate change and reduce CO₂ emissions.
- The potential for solar energy in GCC states is enough high varying between 5.1 to 5.9 kWh/m² year
- The potential for wind energy is moderate in GCC states. The average wind speed in GCC countries is between 3.5 -6 m/s, with the highest average of 6 m/s in Qatar and lowest average of 3.5 in Saudi Arabia
- The readiness analysis showed that while the existing infrastructure is high, the human capital was low.

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