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Evaluating the Role of GCC Nations in Sustainable Energy Investment Using an Enhanced Low-Carbon Economy Index

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Abstract

In the past decade, environmental, social and country governance (ESG) aspects as well as economy have become key factors for decisions in the investment and future development of renewable energy industry. The abundancy of renewable resources and widely accessible technology are the key drivers for the renewable energy business in the GCC. However, lack of effective policies and regulations, along with subsidized fuel prices, are slowing down the implementation of renewable resource options. This study will illustrate the potential, the challenges, and the barriers of implementing renewable energy technologies in the GCC region. In addition, this research empirically examines the impact of renewable energy sources and other factors in the GCC countries. This study can be used as a screening tool, decision making tool, benchmarking tool and guidance of sustainable development.

Introduction

Global energy demand is increasing in the GCC (Gulf Cooperation Council). This is mainly due to population growth, socio-economic growth and urbanization, driven by both oil and gas revenues and growth-oriented policies [1-3]. GCC countries offer the highest access to energy subsidies worldwide. It shows that the high electricity demand and CO2 emissions per capita occur because of a large living population [1]. The GCC oil and gas sector is important because it holds a high share of proven crude oil and natural gas reserves. The region's dependence on fossil fuels makes it vulnerable to the effects of climate change [4]. Global temperatures are getting warmer, which will cause severe consequences such as more intense heat waves, severe droughts, and decreasing rain amount. A rise in the demand for desalination and air conditioning in the region would be due to it being highly stressed with a lack of water [5].

GCC solely use natural gas and oil for electricity needs [6, 7]. Despite increasing costs of fossil fuels, decreasing costs of renewable energy (RE), new RE targets and policies, the share of RE in the power sector has increased [6]. Among all RE sources, solar and wind create the most jobs and money [7]. RE responsible investment model is an option to achieve the main objectives of a low-carbon economy system and to evaluate existing renewable energy industry conditions and the future. Besides, it is a useful investment tool for the investor, and it allows us to measure the sustainability and economy adequately across countries as a benchmark to make a comparative analysis. It also allows us to indicate barriers to investing in renewable technologies. Moreover, that RE model can reflect the four key elements related to renewable energy, which are the country economy, environmental, social, and the governance system, all can play a vital role for the investor to decide to invest in the renewable technologies market.

To meet these RE production goals, GCC countries would have to resolve certain hurdles. They would need to incorporate foreign experience into the project, develop supporting clean energy policies and legislation, and improve currently-built grid infrastructure. Furthermore, solar and wind power are sporadic and natural gas is required for times when power is not needed. There are still issues with sustainable energy sources like wind, solar, waste-to-energy and hydroelectric power which would fail to compete with oil, gas, and coal, although fossil fuel subsidies are still in place [8].

Several studies have surveyed and reviewed the literature on the RE with different aims and objectives. For example, Salahuddin and Gow (2014) investigated the relationship between economic growth, energy consumption and CO2 emissions in the GCC countries [9]. Furthermore, Salahuddin et al. (2015) investigated the relationship between economic growth, electricity consumption, carbon dioxide emissions

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and financial development in the GCC countries [10]. Additionally, Sweidan and Alwaked (2016) studied the effect of economic development and energy intensity on human well-being in the GCC countries [11]. Furthermore, Bekhet, Matar and Yasmin, T. (2017) studies the relationship between CO2 emissions, energy consumption, economic growth, and financial development in GCC countries using dynamic simultaneous equation models [12]. Moreover, Saidi and Hammami (2017) modelled the relationship between transport, economic growth and environmental degradation for 75 countries [13]. Additionally, Salahuddin et al. (2018) studied the effects of electricity consumption, economic growth, financial development and foreign direct investment on CO2 emissions in Kuwait [14]. Moreover, Gorus and Aydin (2019) investigated the relationship between energy consumption, economic growth, and CO2 emission in MENA countries [15]. Furthermore, Li and Lu (2019) examined the multiple effectiveness of a spectrum of indicators chosen from the economy-energy-environment system in China under natural gas consumption [16]. Additionally, Usman et al. (2021) studies the impact of financial inclusion, renewable and non-renewable energy utilization on ecological footprints and economic growth among the 15 highest emitting countries [17]. Furthermore, Yang and Usman (2021) studied the influence of industrialization, economic growth and globalization processes on the ecological footprint and healthcare expenditures among the ten countries with the highest healthcare expenditures [18]. Additionally, Charfeddine and Kahia (2021) examined whether information, communication technology and renewable energy use reduce carbon dioxide emissions reduction in the MENA region [19].

Results indicated no influence of RE on CO2 emissions. It has been suggested that rising CO2 emissions around the world are a serious global threat, and global warming is challenging our planet [20]. The relationship between economic growth and environmental quality is confusing [21]. Concerning the above, the transformation from fossil fuel-based economy to low carbon economy system through encouraging to invest in RE is a crucial matter.

GCC countries must reconcile their ambitions for rapid economic growth with the urgent need for low-carbon development as per Paris Agreement of climate change. The agreement imposed a severe reduction in greenhouse gas emissions take into account the negative sides of environmental issues with the ambition to cut its greenhouse gas emission taking procedures in order to minimize energy consumption and invest in renewable energies as shown in figure1 [1].

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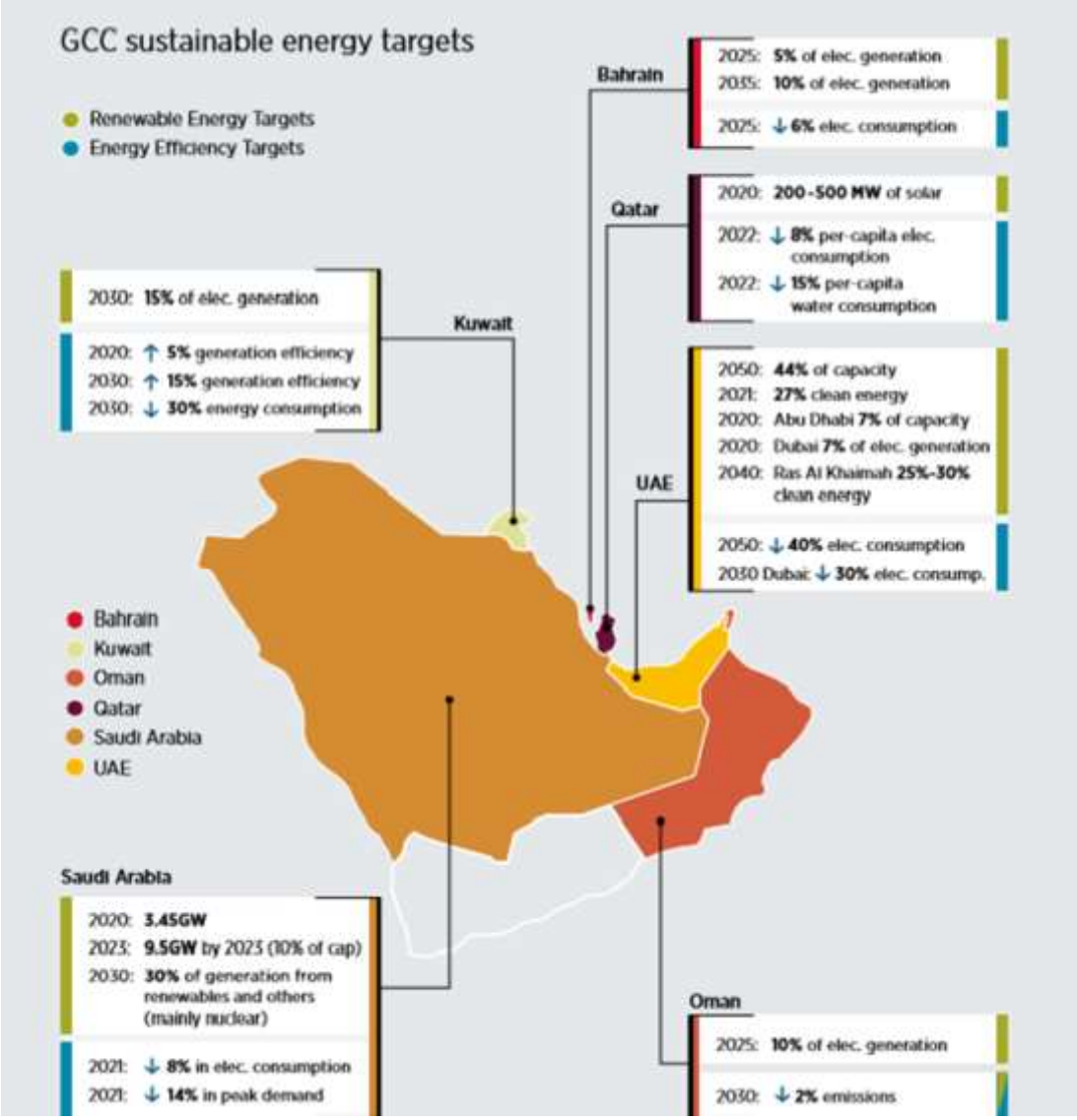

Figure 1. GCC Sustainable Targets

The transformation from fossil fuel-based economy to low carbon economy system through encouraging to invest in renewable energy is a crucial matter due to few issues, as discussed below.

The first issue, the economic growth is unsustainable in GCC countries, and it appears on the current situation of the GCC national economy, which based on the fuel fossil (hydrocarbons) activities, where the forces of supply and demand play a vital role in the capital flow and the production processes of other sectors in the economic structure [22]. The second issue is that GCC countries must secure the energy source by raising the renewable energy share from the total energy mix because the energy demand increases, and the total population increases as well during the years. BP statistical review of world energy 2019 reflects a worrying global picture because the electricity production from renewable energy (solar) ranged between 2% - 0.01% during the years from 2013 to 2018 in GCC countries (refer to figure 2) and the demand for fossil fuel energy increased faster than in the past, where energy consumption appeared to rise during 2008 to 2018 [3].

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	2017 – 2018						2016	2015	2014
Country	PV	CSP	Wind	Biomass and waste	Total RE (in MW)	Share of RE in total electricity capacity	Total RE	Total RE	Total RE
Bahrain	5	0	1	0	6	0.1%	6	6	6
Kuwait	19	50	10	0	79	0.4%	20	1	0
Oman	8	0	0	0	8	0.1%	2	2	1
Qatar	5	0	0	38	43	0.4%	43	42	42
Saudi Arabia	89	50	3	0	142	0.2%	74	74	24
United Arab Emirates	487	100	1	1	589	2.0%	144	137	137
Total	613	200	14	39	867	0.6%	289	262	210

Source: IRENA, 2018a; IRENA estimates.

Note: 2018 data are available only for Kuwait and the UAE. Oman's 7 MW_{th} solar enhanced oil recovery plant and the newly finished first phase of 1 GW_{th} Miraah Solar EOR is not included because this table addresses only electricity. PV = photovoltaic; CSP = concentrated solar power; RE = renewable energy. Totals may not add up due to rounding.

Figure 2. Electricity Production from Renewable Energy in GCC Countries

The third issue is that the regulatory framework of the existing renewable energy is not clear, and the region has recently joined the market for renewable energy and most declared targets not yet enshrined in legislation [23]. So, the transition to clean energy would be slow if willing to compare the GCC energy sector's performance with the radical changes that the sector has undertaken around the world in many countries [23]. The fourth issue, the emission of environmental increased by using fossil fuel energy. All GCC countries signed the Paris agreement of climate change on 22 April 2016 [22]. Besides, the worst scenario projection by the year 2060, the temperature will increase by four degrees centigrade, and it will expose to the negative impacts of climate change on the overall development sectors (Mansoor et al., 2024).

Additionally, it identified that there is a need for low-carbon development to face the challenges of harmonizing its aspirations for economic growth with environmental protection, and there is a demand for new thinking, frameworks, and methods for low carbon development transition and promote clean energy initiatives [24]. Thus, new thought, mechanisms, and strategies for low-carbon development transformation and foster RE projects would be required [24].

Besides, AlKhars (2019) provide an analysis of the quantitative methods used in the electricity research for GCC countries from the period 1983-2018 and it noted that only ten studies from 206 studies based on investment optimization model on their assessment as analysis tool and the study confirmed the fact of the limitation on researcher's assessment based on the Energy-Economy-Environment (E3) model [25]. The study strongly recommended representing finance and money dimensions in order to interact with investment, innovation, and technological change because of this led to a limitation in the evaluation process of climate-related policies. Accordingly, it indicated that financial sectors are critical in models to use for studying the economic impacts of energy system transformations and emissions reductions. Because of this marked increase in electricity demand and the expensive nature of investment in the electricity sector, several academic research papers have been published that address various aspects

of demand and supply in GCC countries. This study aims to evaluating the performance of GCC countries' investment in renewable energy during the ten years ago because the renewable energy plans, ambitions,

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market size, and readiness are varying across them, but the overall picture and their characteristics are one as a dynamic region.

Low Carbon Energy System

On the other hand, the world is seeking to accelerate the transition to a low-carbon energy system, and many countries are moving to draw a road map for the gradual transition to renewable energy by developing a national energy strategy with policies to encourage investment in renewable energy. Other studies highlighted that if the energy transition does not go smoothly, and the oil-exporting countries such GCC countries fail to diversify the economy, it could lead to lower investment in oil sector and increase prices due the existence of many expectations on technologies deployment, cost efficiency, changes in social preferences and government policies in order to address air pollution and climate change and to reduce the growth of oil demand [26].

Solis Avila and Sheinbaum Pardo (2016) subdivided energy use and CO2 emissions by industry and time in Mexico for 1990-2008. They noticed important changes in the structure of three industries which independently lowered emissions for 10 production sectors. The energy intensity and the carbon index were negative in all of the subsectors, except for cement and some other subsectors [27].

Similarly, Niu et al. (2019) demonstrate that energy use and CO2 pollution are positively correlated in eight Asia economies. Given the fact that usage of CO2 pollution per household and energy efficiency of energy is quite poor in the developing world, it is per unit of energy is much higher than it is in the industrialized countries [28]. Arouri, Youssef, M'henni, and Rault (2012) studied the relationship between carbon dioxide emissions, electricity use, and actual GDP across twelve West Africa and North Africa countries between 1981 and 2005. Their research found that in the long-run, there is a positive substantial effect on CO2 pollution through rising energy use [29]. Shahbaz, Nasir, and Roubaud (2018) used panel data on 110 countries and examined the non-linear interaction between foreign direct investment and environmental degradation. The findings show that environmental pollution is observed and this is a consequence of foreign direct investment [30].

Besides, Islam Sarker et al. (2018) considers renewable energy as a good option to accelerate the transition of China's economy from a fossil fuel-based economy to a low carbon economy. However, the study shows that the adoption of low carbon technology based on a sustainable environment and found out some low carbon practices challenges like a heavy pressure on carbon emission, resource endowment, intensive development stream, industrialization, and industrial structure and trade is unplanned [31]. Besides, other studies such as Nyambuu et al. (2020); Shem et al. (2019); and Charabi et al. (2018) investigates LCE transition theoretically and qualitatively, and not considered the incentives and investment in renewables as an essential measure to accelerate the transition. Moreover, it noted that the traditional economic model mostly on the consumption of natural resources and does not build on mechanisms for reducing emissions [24, 32, 33].

Energy, Economy, and Environment (3E)

3E model is a definition of the three major areas of consideration to exploring the sustainability, and it describes as a holistic systemic framework that included three subsystems; resources, economy, and environment [34]. Besides, in this modern clean energy era, growing RE usage is a critical policy priority for both industrialized and emerging economies and many countries would address energy security, sustainable growth, and environmental conservation [34].

Throughout history, the idea of economics has developed from a viewpoint that is primarily based on acquiring resources to one that is systemic, interconnected, and harmonious with community. Numerous studies have been published demonstrating the interrelation between Electricity, Economy, and Climate using the word "3E" [35]. In this way, the eight Millennium Development Goals developed by the United Nations Development Organization at the beginning of the 21st century illustrate the great impact of the triple helix on the global economic scenario. Increasing environmental protection is the seventh of these

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eight aims; energy is a metric to prove it is being achieved. As part of the Sustainable Development Goals [36], an emphasis on affordable and safe electricity is expanding to involve a priority on sustainable cities and societies, or climate change. Due to this, 3E is more popular today than it ever has been.

For some time, the issues connected with 3E have been examined and analyzed in considerable detail, which are only encountered in the past. The scholarly group has effectively united all three components through an array of varied study initiatives [37]. One of the study studies focuses on the energy efficiency of industrial units as a predictor of economic growth of a city. In the other side, the effect of human activity on the condition of natural resources and the effects of human pursuits are defined [38]. Some scholars examine the long-term feasibility of cleaner energy without looking at emerging economies [39].

Studies consider the quality and effectiveness of energy sources as they are utilized in various settings, and how it impacts efficiency and effectiveness. For example, the solid waste recycling strategy in Brazil to solve the issue of the increasing amount of electronic waste because of a rise in the usage of modern technology and electrical resources, or the effect of effective coal waste management by utilizing environmental indicators that define the combustion of various ranges of coal (gas, flame, coke, or uncooked coal) [35].

A consideration utilized by the scientific group is RE, which connects the three components in an essential manner. By integrating RE sources into the economy, the framework adapts the production of the supply chain by allowing use of natural capital. For example, an applied sustainability model that is used to explain how improvements in the bioenergy sector can affect environmental policies, economic growth, and culture, demonstrating that an improvement in the share of bioenergy in total electricity production will stimulate the electricity market [40].

Other scholars follow this pattern around energy from various perspectives: a reorientation of efficient energy distribution towards others, such as biogas, biodiesel, or bioethanol to close the carbon loop in nature; the achievement of a defined target of carbon dioxide elimination within the process of Modeling and Optimization of Negative Emission Technologies (MONET) [41], or a study of the effect of conventional and RE options on economic development, the transport market, and the carbon dioxide emissions. Furthermore, another highlighted line of inquiry focuses more on the social agricultural aspect: through a legal and educational approach of the problem, the implementation of the principle of eco-efficiency to determine the suitability of RE to multi-target models or a qualitative comparative review to research the connection between economic development and the atmosphere.

Therefore, the most important representation of the union of these principles is contained in environmental sustainability, which was first stated at the UN Conference on the Environment held in Stockholm in 1972. Since then, the issue of how to boost the economic strength of countries is connected to the constraints the natural world imposes, and it has manifested in various research papers that link economy to the environment. It is resilience that can satisfy the economy's needs and the environment's requirements [42].

In line with the aforementioned methodology, some scholars rely on the following methodologies: evaluation of the social and environmental effects of these practices by utilizing life cycle assessment approaches, agency theory, or the creation of various metrics. On the one side, other scholars examine the relation between various agents of the economy and sustainability in a country: foreign corporations or customers. However, there is no literature to discuss the new developments in curriculum. From this angle, it can be shown that the junction of the three concepts fosters an emphasis on CO2 pollution as well as sustainability studies [43].

Social Responsible Investment (SRI)

The incorporation of social and environmental factors in investment decisions. SRI is a technique that promotes business strategies that emphasize socially conscious practices like impact investment, shareholder engagement, and collaborative investing [44].

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Within SRI, it is described as "an ethical investments, responsible investments, sustainable investments, and any other investment process that combines investors' financial objectives with their concerns about environmental, social and governance (ESG) issues" [44].

In recent years, the issue of corporate accountability and company responsibility has been posed in view of the spectacular growth of social responsibility metrics. The sum invested in socially conscious funds has risen tremendously over the years, and even conventional investors are starting to apply ESG scores to their portfolio selection requirements [45].

In a seminal contribution, Hart and Zingales (2017) describe the goal of a capitalist associated with community, who aims to avoid social costs. They assert that companies should rely on optimizing shareholder welfare rather than shareholder worth [46]. Socially conscious investors demonstrate prosocial actions in our model, but only concern themselves with externalities because they are not personally responsible for them [46]. Chowdhury and Paul (2018) explain how countries use the finance system to not meet social objectives. A recurring thread with our paper is that socially-minded clients trust the firm's socially-advisable policies. However, their research focuses on how socially-minded investment companies may blunt a firm's profit incentive while encouraging the firm to concentrate on social objectives [47].

Landier & Lovo (2020) demonstrate how quest frictions in financial markets will cause an ESG fund to influence production decisions, and how their effect can flow through the supply chain [48]. Roth (2019) contends that impact crowdfunding is preferable to conventional charities, noting the willingness of donors to withdraw money as a possible benefit [49]. The paper by Gollier and Pouget (2014) explores how activist investors may profit by restructuring a company and eventually selling it back to the public [50].

Finally, socially conscious investors are driven to support society and are distinguished by an optimistic outlook towards reducing social costs. The reasoning behind SRI is to realize the risk-return tradeoff while investing in today's environment. Its priorities are focused upon environmental concerns and human rights, and aims to promote group engagement and relationship-building [51].

Methodology

The purpose of developing a conceptual framework at the starting point is to present the country's performance evaluation process to determine the multi-dimensional aspects to measured and formulate the structure of the (RERII) index as a platform for investors and other interests [52]. The study covered six GCC countries (Saudi Arabia: SAU, Oman : OMN, Kuwait: KWT, United Arab Emirates: UAE, Qatar: QAT, and Bahrain: BHR) and measuring four dimensions of renewable energy responsible investment: Economic Pillar, Environmental Pillar, Social Pillar and Country Governance Pillar. The analysis process based on the investment index included four multi-dimensional factors of renewable energy responsible investment: Economic, Environmental, Social, and Country Governance factors. The overall score for each country based on 19 different quantitative indicators that reflect the relative country performance and renewable energy industry in a particular indicator (Lee et al., 2014). The data was generated from various entities such as IMF, TE, UNCTAD, IEA, BP, IRENA, IPCC, WB, ESCWA, and REN21. Lee and Zhong (2015) find that min–max normalization is helpful in specimen building [52].

Economic Pillar: Economic instruments are chosen to reflect the overall economic strength and the environment of investment in GCC counties. It includes factors: GDP annual growth rate, debt to GDP ratio, currency movement, interest rates, foreign direct investment, unemployment rate, and fossil fuel subsidies.

Environmental Pillar: The following indicators assess the overall sustainability of the country environment at the national level: carbon dioxide emission from fossil fuel per population, electricity production from oil, gas, and coal sources, electricity generation from renewables, and renewable energy resource.

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Social Pillar: Social investment discusses the delivery of energy use and output and associated programs that respond to basic human needs to design a better standard of life while reducing the usage of natural capital and reducing greenhouse gases. It includes factors: the electricity power transmission and distribution losses, electricity consumption per capita, availability of latest technologies, affordability of financial services, and capacity for innovation.

Governmental Pillar: This tests the perception of government programs, the policy development and execution, and the legitimacy of the government's dedication to public policies. It includes factors: control of corruption, governance effectiveness, political stability, regulatory quality, rule of law, and voice and accountability.

Results and Discussion

Renewable energy is an effective tool to mitigate climate change, and the GCC countries support efforts to address climate change and try to implement efficient policies and strategies to fight it. This study explains that the energy sector in the GCC countries is the main contributor to CO2 emissions. This study explores the impact of multiple variables, underscoring the importance and necessity of considering reform and regulations to minimize energy consumption.

From the annual values of each GCC country, a comparative analysis can be carried out to measure the overall performance based on the economic, environmental, social and country governance aspects. The results summarized in Tables 1 shows the rankings of countries regarding the overall performance and breakdown of 2019.

Table 1. GCC Countries Scores and Rankings In 2019

Rank	**Country**	**Econ.**	**Env.**	**Soc.**	**Gov.**	Renewable Energy Responsible Investment Index
1	United Arab Emirates	5.27	18.46	15.13	14.43	53.29
2	Oman	3.55	15.88	15.46	16.87	51.77
3	Saudi Arabia	0.82	17.10	10.45	15.25	43.61
4	Kuwait	6.28	15.12	9.19	12.72	43.31
5	Qatar	4.20	17.16	15.44	4.47	41.27
6	Bahrain	8.12	17.46	8.44	6.53	40.55

Among the group of GCC countries, United Arab Emirates was the most outperforming country and ever ranked 1th place. However, most of GCC countries ranked below the bottom half. This demonstrates that there is a week correlation between the status of economic development. On the other hand, Bahrain constantly ranked in down in the bottom half.

The performance of economic indicators effects significantly the renewable energy investment for low-carbon economy. The results indicates that Interest rate (-0.81), unemployment (-0.75), and FDI growth (-0.90) have negative impact, while GDP growth (0.47), currency movement (0.61), debt to GDP (0.24), and fossil fuel subsidies (0.27) have positive impact for renewable energy investment for low-carbon economy for t-statistics test.

The performance of environmental indicators effects significantly the renewable energy investment for low-carbon economy. The results indicates that carbon dioxide emission from fossil fuel per population (6.40), electricity production from oil, gas, and coal sources (1.21), electricity generation from renewables, and

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renewable energy resource (0.39) have positive impact for renewable energy investment for low-carbon economy for t-statistics test.

The performance of social indicators effects significantly the renewable energy investment for low-carbon economy. The results indicates that capacity for innovation (-2.02), has negative impact, while electricity power transmission and distribution losses (1.75), electricity consumption per capita (4.52), availability of latest technologies (3.17), and affordability of financial services (0.96) have positive impact for renewable energy investment for low-carbon economy for t-statistics test.

The performance of country governance indicators effects significantly the renewable energy investment for low-carbon economy. The results indicates that voice and accountability (-0.17), has negative impact, while control of corruption (1.03), governance effectiveness (1.91), political stability (0.19), regulatory quality (2.18) and rule of law (1.85) have positive impact for renewable energy investment for low-carbon economy for t-statistics test.

Conclusion

This study explores the renewable energy investment for low-carbon economy in GCC countries. To test the long-term relationship among the economic indicators, environmental indicators, social indicators, and governance indicators variables, the study bounds testing approach for the period of ten years end at 2019. Despite some variables being stable, the stationarity results indicated strong evidence that all variables are stationary after the first difference. The empirical results proved the existence of a long-term equilibrium relationship among renewable energy investment for low-carbon economy with CO2 emissions, afford of fin ser, avail of tech, electricity consumption per capita, electricity power transmission and distribution losses, gov effectiveness, regulatory quality, and rule of law in all GCC countries. From the short-run disequilibrium among the variables is corrected in each period to return to the long-run equilibrium level.

The findings of this study have important policy implications for GCC not only in terms of environmental perspective but also offering the allocation of financial resources for future planning. The GCC countries have recently adopted a more anticipatory approach to addressing environmental issues on the international, national, and regional levels. However, the remodel strategies have not yet resulted in the development of consistent policies on ecological modernization.

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