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Article

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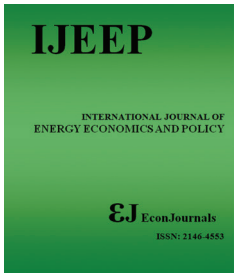

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Exploring the Impact of Renewable Energy on Climate Change in the GCC Countries

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ABSTRACT

This study provides a theoretical framework for the role of renewable energy in mitigating the climate change in the Gulf Cooperation Council (GCC) countries. 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 in reducing the carbon dioxide emissions, using pooled ordinary least square regression analysis with fixed effect specification. The results indicate that renewable energy consumption, GDP per capita, and electrical power consumption have a statistically significant impact on CO_2 emissions.

Keywords: Renewable Energy, Electrical Power, GCC Countries
JEL Classifications: Q20, Q30, Q40

1. INTRODUCTION

The Gulf Cooperation Council (GCC) economies rely overly on hydrocarbons for energy production. Burning huge amounts of these fossil fuels domestically is not a sustainable process. The rapid socio-economic growth, characterized by increasing population, high rates of urbanization and substantial industrialization, consumes more and more energy to fulfil basic requirements. Demand for electricity is accelerating; it doubled during the last decade and is expected to keep growing by approximately 7-8% annually (Aloughani, 2015).

The high demand for energy in the GCC region causes excessive and inefficient hydrocarbon use that in turn is damaging the environment and human health. Since the nineteenth century, scientists and researchers have studied the influence of Greenhouse Gas (GHG) on the atmosphere. Recently, concerns have grown because of the global climate change issue caused by the rise of the accumulated GHGs. Oddly, few controls and monitoring existed for one of the major GHGs, carbon dioxide. CO_2 concentration has increased to reach about 400 parts per million (ppm) of atmospheric concentration.

Climate change is considered as the most severe environmental phenomenon and the greatest threat to the world. Daily human activities, such as transportation, farming, deforestation, industrialization, and manufacturing, produce GHGs. Global warming and the ensuing climate change are regarded as a result of man-made GHG emissions, including water vapor, carbon dioxide, methane, nitrous oxide, and ozone. These gases accumulate in the atmospheric space, entangle the heat from the sun, and, consequently, cause climate change. These changes have led to catastrophic events like storms, droughts, rise in sea levels, and floods (Scientific Advisory Panel, 2018). With the burning of fossil sources of energy in the Gulf states causing CO_2 emissions, global climate change will cause serious negative environmental impacts on the region. Agriculture and water resources will be affected by the rising temperatures. As the evaporation increases,

the demand for energy will increase. Furthermore, the levels of the Red Sea, the Arabian Gulf, and the Indian Ocean will rise, and the risk of desertification and salinization of soil and groundwater will become real threats.

To address climate change, GCC countries established a framework to promote clean and renewable energy solutions as a path to sustainable development, as well as to protect the environment. Therefore, GCC countries have joined many international environmental agreements such as The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol of climate change. The UNFCCC obligated industrialized countries and "transitioning economy" countries to achieve quantified emission reduction targets for GHG. The Kyoto Protocol was signed by 192 parties, including the GCC countries, and it took effect on February 16, 2005 (Raouf, 2008).

Renewable energy sources (RES) comprise solar, wind, hydropower, and other sources. RES are relatively clean, widely available, and unlimited. In addition, RES are the only sustainable alternative to fossil fuels. According to Besha (2011), RES currently supply about 15-20% of world energy demand. It is evident that as renewable energy technology matures and becomes widely implemented, the cost gap between it and traditional energy sources will be minimized. Closing this gap enables RES to become cost effective compared to conventional energy.

This paper is organized as follows. Section (2) encompasses the relevant literature review and previous studies. Section (3) details the theoretical framework that explains the RES phenomenon and analyzes the challenges and barriers of RES Technology in the case of the Gulf countries. Section (4) describes the methodology and empirical work. The interpretation of the descriptive results are in section (5); and conclusions are in section (6).

2. LITERATURE REVIEW

Many studies in renewable energy systems emphasize that renewable energy must be now a priority for all countries worldwide. Scholars illustrate the vital role of renewable energy in mitigating climate change and study how beneficial is the utilization of the world's renewable resources. Some scholars pay special attention to the GCC's energy market and RES.

Various studies have found a significant association between sustainable growth and a diversified economy. Some countries are considered successful models in economic diversification. GCC countries attempt to achieve the best level of growth and prosperity by diversifying the economy to avoid the instability linked to the over-reliance on oil resources (Saif-Alyousfi et al., 2018).

Poudineh et al. (2016) shows that resource-rich MENA economies are still behind in the move towards renewable energy because of infrastructure inadequacy, insufficient institutional capacity, risks, and uncertainties. The authors suggest a new dynamic approach consisting of a partial subsidy program and a partial fossil fuel price adjustment to balance fiscal sustainability with political stability. This policy approach might lead to more development in the renewables markets.

Aloughani (2015) discusses the challenges of RES strategies in the GCC countries. The author explains that because the nature of the Gulf countries is convenient for RES, these resources are considered as the new vision for future energy. However, many challenges are associated with renewable energy technologies such as economic, technical, social, and environmental. A cost analysis between traditional energy using oil and gas and RES energy finds that many producers accept the concept of cutting subsidies on traditional energy to promote RES.

Ley (2017) highlights the fact that decentralized renewable energy (DRE) projects contribute to climate change mitigation, e.g. provide electricity that can reduce over-dependence on natural resources. DRE systems are utilized for emissions reduction and poverty alleviation, but their role for climate change has yet to be analysed. Ley's study shows that despite the wide variety of applications of DRE systems, the applicability of these systems towards climate impacts are not considered.

Luttenberger (2015) Illustrates that Croatia with its massive renewable solar energy potential still underperforms in solar usage for electricity production and heating. Luttenberger highlights the reasons for this by analysing Croatia's environmental policies and subsidies, international financial institutions financing new renewable energy projects, the power of utility companies, and the social dimension of RES. To secure reasonable renewable energy shares in Croatia's energy supply mix, the government should act as a regulator with various instruments to enhance the renewable energy use in cooperation with local authorities.

Sasana and Putri (2018) discusses the increase of energy consumption that has become one of the world problems, especially in developing countries moving toward industrialization, like Indonesia. Sasana and Putri analyzes the effect of fossil energy consumption, population growth, and consumption of renewable energy on carbon dioxide emission. The result, using an ordinary least square (OLS) approach, showed that fossil energy consumption and population growth have a positive influence on carbon dioxide emissions in Indonesia. On the other hand, the estimated renewable energy consumption (REC) has a negative effect on carbon dioxide emissions.

The study conducted by Mas'ud et al. (2018) discusses the progress made on solar energy in the GCC countries. They propose a plan to increase the share of RES by deploying solar energy for electrical power production and simultaneously reducing the huge dependency of GCC countries on fossil fuels. To emphasize this approach, governments must promote relevant policies and inform their citizens about the benefits of RES. Some of the challenges and barriers facing the GCC countries are technological know-how, policy development, and insufficient application of RE technology integrated within the buildings. However, many areas of improvement are evident through promotion of research and development, public/private initiatives, legislation, and regulatory framework.

Gastli and Armendariz (2013) report that according to the World Economic Forum, the GCC nations will be affected by climate change, producing increased pressure on scarce water resources and rising air pollution. The authors present the challenges of the application of renewable energy in the GCC countries. They highlight that the Efficiency Reduction vs. Cell Temperature is the suitable technology for the GCC and find that the performance of solar cells in the GCC region will not be similar to their counterparts operating in Europe. The study also discussed the reasons behind the lag in the application of renewables in the GCC region. Those reasons are: insufficient awareness among decision-makers, low investment, the fear of shifting from conventional energy sources to renewable and clean energy sources, lack of clear regulations and policies, lack of industrial motivation and lack of expertise and specialization.

Tugcu et al. (2012) primarily examined the long-run and causal relationships between renewable and non-REC and economic growth by using classical and augmented production functions in G7 countries (1980-2009). The findings show that neither renewable nor non-REC are related to economic growth.

Mathiesen et al. (2011) illustrate that the high cost of GHG mitigation strategies dominate the debate between world leaders about the costs of mitigation and the distribution of these costs between different countries. The analysis reveals that implementing renewable energy and efficient conversion technologies have a positive socio-economic effect, create employment, and potentially lead to high earnings on externalities, such as positive health effects.

Shafiei and Salim (2014) attempt to capture the determinants of CO_2 emissions, using the STIRPAT model with panel data from 1980 to 2011, for OECD countries. The results show a positive correlation between CO_2 emissions and non-REC. Alternatively, the more consumption of RES, then the less CO_2 emissions. The results include an environmental Kuznets curve (EKC) between urbanization and CO_2 emissions, indicating that with higher levels of urbanization, the environmental impact decreases.

Roca et al. (2001) studied the relationship between environmental pollution and economic growth utilizing the EKC hypothesis. EKC shows the positive relationship between income and environmental degradation in the short run, as the economy grows, while in the long run, this relationship reverses (i.e. U-shaped). However, the empirical evidence to support the hypothesis of a U-shaped relationship between environmental degradation and economic growth is still criticized. The following studies also are related with energy-growth nexus the GCC countires: Al-mulali et al. (2019), Salahuddin et al. (2015), Salahuddin et al. (2018), Hassine and Harrathi (2017), Saqib (2018), Sbia et al. (2017).

3. THEORETICAL BACKGROUND

3.1. Types of RES for GCC Countries

1. Solar: sunlight that can directly heat and light different types of buildings and plants. Solar architecture technologies used are passive solar design and active solar air and water heating thermal power systems.
2. Ultra Efficient Solar Cells: regular solar panels usually convert less than 20% of solar energy into electricity, but this new technique doubles the power efficiency of solar devices.
3. Wind: the heating and cooling of the earth by winds transformed into energy. Wind technology can be land-based and/or offshore, using wind turbines.
4. Hydropower: energy generated from moving (falling or running) water. Hydropower plants use a pumped storage.
5. Biomass: energy obtained from organic matter (ultimately from photosynthesis) through burning and digestion of wastes from municipal animals, humans, industrial, and agricultural sources. Biomass can be used to heat water, producing steam that drives turbines, as in traditional power plants.
6. Geothermal: energy generated from hot dry rocks and high enthalpy sources.

3.2. Renewable Energy and its Barriers in GCC Countries

Many countries, especially Gulf countries, try to use renewable energy as a substitute for conventional fossil fuels. Despite the new technology benefits and effectiveness, its application faces many challenges and obstacles. Government policies, public awareness, poor knowledge, lack of political support, and cheap oil and gas prices are some of the structural barriers to the use of RES. Additionally, dust, heat, and humidity comprise major environmental obstacles for such energy generating technologies.

According to Wee et al. (2012), The Union of Concerned Scientists classified barriers to RES into four categories.

First, commercialization ses and baseless tax when comparing RES and other energy sources create a barrier. The mbarriers exist as the new technologies compete with traditional ones. Subsidies that display price biaarket is not reflecting the social cost, and there is insufficient information about RES.

The cost of RES is a major concern to most governments. Fossil fuel costs influence the cost of electric power and have affected the market price and consumption of RES. Many legislations and plans are employed to minimize the gap between the prices of fossil fuels and RES by applying certification or tax refunds. On the other hand, even though some RES are expensive, they are more attractive when considered in the context of volatile fossil fuel prices.

3.3. The Negative Impact of Fossil Fuels on the Environment

Conventional energy sources are limited in quantity and severely harmful to the environment. According to the US Scientific Advisory Panel (2018), the burning of fossil fuels was responsible for 79% of US GHG emissions in 2010. Atmospheric CO_2 has increased by nearly 30%, and the average global temperature has risen by 0.3 (0.6°C) in recent decades (Chakraborty et al., 2000). Many studies, scholars, and authorities, such as the International Energy Agency, explained that the burning of fossil fuels releases carbon dioxide and other GHGs into the atmosphere and is most hazardous to humans and the environment.

According to the UN Intergovernmental Panel on Climate Change Report (AR6 Climate Change 2021: Impacts, Adaptation and Vulnerability), it is evident that climate change causes many natural disturbances worldwide, such as melting ice caps and an increasing number of extreme weather events. Furthermore, it is anticipated that 75-200 million people are at risk of flooding by coastal storm due to a mid-range climate change. A sea level rise of 40 cm is predicted by the 2080s.

3.4. The Negative Impact of Fossil Fuels on Human Health

Many researchers and studies illustrate the effect of climate change on human health. Mukhopadhyay and Forssell (2005) concluded that changes in the broad-scale climate system would affect human mortality and morbidity, due to extreme heat and a higher level of air pollution. Patz et al. (2005) found that 40-60% of acute respiratory infections are due to environmental problems. They concluded that, as the current consumption of fossil fuels is expected to increase 120% by the year 2020, more than 6.34 million people will die per year in developing countries due to emissions concentrations of particulate air pollution. They reported that carbon monoxide is an extremely toxic gas and the source of photochemical smoke.

Smith et al. (1999) assert that climate change in the form of heat waves, floods, and drought can lead to sunburn and melanoma. They add that climate change is primarily responsible for causing heat stroke, drowning, and gastrointestinal diseases. Therefore, GHG emissions must be reduced by 60-70% to maintain the atmosphere and limit the harmful effects to the ecological system.

3.5. GCC Countries' Approach to Environmental Sustainability

GCC countries experienced a significant growth and development of infrastructure. In parallel, the electricity and water desalination sectors, which depend on oil and gas, face remarkable growth as well. The consumption of electricity in GCC countries has increased by 12.4% from 2005 to 2009 with an average 3.15% annually. The average watts per person of 1149 in 2005 in the GCC countries was already almost three times the world average of 297 watts per person (Mondal and Khalil, 2012).

Because misuse of fossil fuels to generate electricity and sea water desalinization increase GHGs, the GCC countries need to enforce progress in reducing carbon emissions. GCC countries are among the top 25 emitters of carbon dioxide per capita, contributing 2.4% of GHG emissions per capita worldwide. The GCC countries planned to mitigate carbon emissions and other environmental issues by signing the Kyoto Protocol treaty (United Nations, 2006). These agreements, in alignment with the GCC environmental policies, encourage and support the usage of RES locally to limit harmful emissions and reduce the negative effects of climate change. Therefore, the GCC governments, along with the private sector and the general public, cooperated to shift from being merely oil producers into RES producers. They also stated the financial, technological, and ecological benefits and costs from such projects (United Nations, 2006).

Saudi Arabia and the UAE have inadequate potential (2.5-4.5 m/s) for wind power, but Bahrain, Kuwait, Oman, and Qatar have at least moderate opportunities (5-7 m/s). The conditions for solar energy potential in the GCC are among the most favourable globally (Reiche, 2010). Many activities support RES application. For example, King Abdul-Aziz City for Science and Technology in Saudi Arabia conducts special research on solar energy and funds projects for RES Technologies, following similar initiatives in the US and Germany. The Kuwait Institute for Scientific Research, and the Middle East Desalination Research Center are successful examples of solar cooling system installations. The Oman government supports Omani manufacturers and industries in utilizing RE sources. Qatar joined the United Nations Conference on Environment and Development, established a link among different channels of renewable energy technologies through an international database, and encourages Qatari colleges and universities to conduct RE research. As Organization of the Petroleum Exporting Countries members, the GCC countries pledged $750m (US) to fund carbon capture and research (Copenhagen summit report, 2009).

3.6. Wind and Solar Energy Sources in the GCC

The environment of the GCC countries is well-suited for RE, due to unlimited, free solar and wind resources. The GCC countries experience a high level of solar radiation exposure during the daylight hours, and approximately 1,400 hours per year of full load of high-speed wind. Solar radiation levels throughout the GCC are greater than levels of solar radiation in areas where there are solar photovoltaic and solar thermal technologies. The full load of wind enables the use of wind power generation technologies (Aloughani, 2015).

The development of solar energy is possible due to the daily average of nine hours of sunshine, low levels of rainfall, low cloud cover, and spacious lands (about 98.3% empty deserts). In terms of generating economically feasible wind energy, the average speeds across the Gulf region lands are in the range of only 4.5-5.5 m/s. The most favourable site for wind is along the Red Sea coast to the south (Aloughani, 2015). UAE and Qatar are the leading GCC countries in utilizing RES. Additionally, the three wind turbines that are expected in Bahrain will help generate 15% of its energy needs (Alnaser and Alnaser, 2009).

Due to the high cost of the new RES technology, the involvement of the private sector, supported by taxes and customs exemptions, along with the involvement of public and governmental authorities is essential. Financial supports in the form of subsidies, lands for installation, and the operation of RE generating plants are required.

3.7. Challenges to the Implementation of RE in GCC

Cost is the first challenge to implementing RE in GCC countries. High cost differentials make RES unable to compete with conventional power generation, because water, fuel, and electricity are heavily subsidized. At the same time, low electricity costs fail to incentivize consumers to efficiently use energy. Moreover, scarcity in land endowments in Qatar and Bahrain increase costs for RES.

Regional environmental conditions impede the implementation of RE in the GCC countries. Direct solar radiation is reduced due to dust and weak performance of the Concentrating Solar Power system due to high humidity. Infrastructure regulations limit RE implementation; grid-tied RES systems are not permitted in some countries yet. In addition, most grids are not well-equipped to handle the dynamics of solar energy systems.

Two related impediments to RE implementation are public awareness and knowledge. Lack of public awareness and understanding of climate change and its negative implications deter the implementation of RE. Data on the actual performance of solar systems, including weather data, are limited. Additionally, limited R&D resources to develop and adapt solar technology to the exceptional climate circumstances impede the implementation of RE. The RES industry requires qualified expertise, technicians, and designers. There are several research institutes in the GCC, but research outputs are slow and still ineffective.

The current legislation and regulatory framework in the GCC countries is another challenge to RE implementation. Despite some successes in the field of RES, there are still some limitations due to national policy framework strategies and a lack of national policy strategies to promote RES. Public/Private initiatives for RES development can drive direct foreign investment in RES to the region. Currently, these programs are inadequate; therefore, limiting investment in RES in the GCC countries.

4. EMPIRICAL STUDY

Identifying the relationship between renewable and non-REC and emissions is worth an academic investigation. Numerous studies have dealt with the relationship between energy consumption and pollutant emissions. These studies have been performed in different countries, various modelling methods, and findings. However, to the best of researchers' knowledge, only a few studies have investigated the relationship between energy consumption and CO_2 emissions.

4.1. Methodology and Datasets

This analysis is conducted to investigate the relationship between energy consumption and CO_2 emissions. In this study, an econometric model is proposed using panel data of the GCC states between 1998 and 2015. The estimated model is carried out to examine the relationship between several independent variables and CO_2 emissions using the pooled OLS procedure. All data are obtained from the World Development Indicators (WDI) online database. All the variables are transformed to logarithms for the purpose of the analysis.

Many empirical works address the issue of CO_2 emissions empirically across different countries using different methods, but very few researchers capture the same issue for the GCC countries. Therefore, this paper is following the recent empirical literature of Sulaiman, et al. (2013), using the same hypothesis from their research and expanding on it. This framework contributed to a better understanding of the factors that could significantly affect CO_2 emissions in the GCC region and allowed for measurement of the impact of REC on CO_2 in GCC countries. The main restrictions in the study are data limitations.

It is possible to test the long-run relationship between CO_2 emissions, economic growth, and the rest of the variables in a linear function. The equation is structured by a dependent variable and four independent variables, and the model is estimated through the following equation, using the pooled OLS method:

$$E_{it} = \beta_0 + \beta_1 GDPC_{it} + \beta_2 REC_{it} + \beta_3 RFW_{it} + \beta_4 ELP_{it} + \varepsilon_{it.} \quad (1)$$

Where E represents CO_2 emissions in metric tons per capita. Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. (GDPC) represents real GDP per capita. (REC) represents REC. It is the share of renewable energy in the total final energy consumption. (RFW) represents renewable internal freshwater resources per capita (cubic meters), which refer to resources like internal river flows and groundwater from rainfall. (ELP) represents electric power consumption in kilowatts per hour per capita. Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses, and own use by heat and power plants. ε_t is the standard error term.

Twumasi (2017) finds a positive correlation between GDP and CO_2 emissions. Therefore, we expect to have a positive effect between GDPC and CO_2 emissions. On the other hand, renewable energy leads to decreasing CO_2 emissions, so the expected signs of the coefficients related to REC and RFW variables are negative. Finally, the ELP coefficient is expected to be positive.

Initially, equation 1 is examined using the pooled OLS across the GCC countries without taking heterogeneity into account. Then, the equation is examined using random effect model and fixed effect model. So as to decide the more proper model, the Hausman test is conducted to determine the more proper approach. According to the Hausman test, the fixed effect model is the best model.

4.1. Data Descriptive

The data included in this paper cover the six GCC countries and are obtained from reliable sources. The data are obtained from the World Bank through WDI. WDI are a collection of indicators compiled from officially recognized international sources. The World Bank data present the most current and accurate global development data available and include national, regional and global estimates. Data for GDP per capita is measured in current local currency.

5. EMPIRICAL RESULTS

The basic model is estimated by the pooled OLS method. Coefficients varied in significance level, magnitude, and expected signs. The results of that model appear in Table 1.

Table 1: Pooled OLS regression model (N=1660)

Variables	Coefficients	Standard Error	t-statistics	P-value
GDPC	0.1723141	0.0044151	39.03	0.000
REC	–4.116207	0.1862659	–22.1	0.000
RFW	–0.0001292	0.0028706	–0.04	0.964
ELP	0.6014481	0.0103708	57.99	0.000
Constant	–4.099764	0.0994582	–41.22	0.000
R-squared		0.7815		

OLS: Ordinary least square

Table 2: Fixed Effect Model (N=76) (5% significance level)

Variables	Coefficients	Standard Error
GDPC	−0.1015606	−0.0089469
REC	−5.233155	−0.3733545
RFW	0.0013493	−0.0014587
ELP	1.103242	−0.0280573
Constant	−5.982706	−0.2214249
R-squared	0.5773	

According to Table 1, the results show that GDPC is statistically significant at 1%, indicating that there is a correlation between GDPC and CO_2 emissions. The magnitude and positive sign suggest that for a 1% increase in GDPC, the CO_2 emissions will increase by 17.2%. Moreover, this finding is consistent with our expectations. The estimated coefficient for REC is also statistically significant but with negative sign. This coefficient suggests that for a 1% increase in REC, the CO_2 emissions will decrease by 41.16%, leading to less GHGs. This result is also consistent with our theoretical expectations and is consistent with Sasana and Putri's (2018) findings for fossil energy consumption and REC. On the other hand, renewable internal freshwater resources flow (RFW) is statistically insignificant, indicating that there is not a statistically significant relationship between RFW and CO_2 emissions. Finally, ELP is statistically significant with a positive sign. The magnitude of the coefficient suggests that for a 1% increase in ELP, CO_2 emissions will increase by 60.14%. The result is consistent with theory.

The Hausman test is conducted to select the proper approach for this study. It shows that the P-value is significant at 2%. Therefore, the null hypothesis of random effect can be rejected, and the fixed effect model is used for estimations. Table 2 shows the results of the fixed effect and the random effect models.

According to the FE model, *GDPC* gave the unexpected sign, that is higher economic growth causes a reduction in CO_2 emissions. This result is against the finding of Twumasi (2017). This could be interpreted as higher income encourages governments to work towards adopting new methods that reduce CO_2 emissions. REC is statistically significant across the GCC countries and has a negative sign. The negative sign for the REC coefficient suggests that with more renewable energy utilization in the GCC, the CO_2 emissions to the atmosphere will be reduced. On the other hand, RFW is shown insignificant, which means it has no relationship with the CO_2 emissions variable. *ELP* is found to be significant with a positive relationship with CO_2 emissions as theoretically expected. More electrical power consumption leads to a higher level of GHGs.

6. CONCLUSION

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 CO_2 emissions, which is the major component of GHGs. This research explores the impact of multiple variables on CO_2 emissions, underscoring the importance and necessity of considering reform and regulations to minimize energy consumption. Abundant renewable resources, along with high technology adoption, will support the renewable energy business in the GCC countries.

Using pooled OLS regression analysis, this research finds that RES contribute in reducing the carbon dioxide emissions. The results indicate that GDP per capita, REC, and electrical power consumption have a statistically significant impact on CO_2 emissions in the GCC countries. Similar results were found by the FE model, except that GDPC gave the opposite sign. This proves this variable could possibly have different effects as explained earlier. Further studies are crucial to determine this issue.

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