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Effect of Renewable Energy Consumption on Economic Growth in Kenya

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ABSTRACT: One of the significant economic growth problems in Kenya is the income inequality and poverty rate which has made it impossible for among the households to afford clean energy. While the country has experienced some economic growth over the years, it is not yet clear whether the adoption of renewable energy has been the cause of this growth. There have been mixed results on the studies done on renewable energy use and their effect on economic growth and therefore calls for further research. The general objective of the study was to determine the effect of renewable energy consumption on economic growth in the Kenyan economy. Specifically, the study specific objectives were to determine the effect of solar energy consumption, geothermal energy consumption, and hydroelectric energy consumption and wind power energy consumption on economic growth in Kenya. This was made possible through an analysis of 37 years' data from 1986 to 2022 on an annual time series basis. This study employed the endogenous growth theory as the main theory of the study and triple bottom line theory as the supplementary theory. The study employed an explanatory research design and analyzed data using the Autoregressive Distributed Lag model to establish whether renewable energy consumption had any effect on economic growth of the Kenyan economy. Findings of diagnostic test demonstrated that there was no multicollinearity among the independent variables, residuals were homoscedastic, and there was no autocorrelation among the residuals. The results of the Jarque bera normality test showed that the study's variables were normally distributed. The Augmented dickey fuller unit root test both showed that there was no unit root and that the variables had a short run relationship. Additionally, the model's stability over time was confirmed by the CUSUM test. Findings of the study were: the relationship between hydroelectric energy consumption and economic growth was positive and significant, wind power energy consumption and economic growth was positive and significant and between geo-thermal energy consumption and economic growth was positive and significant. The study concluded that geo-thermal energy consumption, hydroelectric energy consumption and wind power energy consumption significantly affect economic growth positively. The study therefore recommends that the Kenyan government should set ambitious targets for renewable energy consumption such as a specific percentage of electricity generation or overall energy consumption. The Kenyan government should enhance and enforce regulatory frameworks specific to renewable energy in order to provide a stable and predictable investment environment. Finally, the Kenyan government should focus on expanding access to renewable energy solutions in rural areas, where energy access is limited. Implementing off-grid renewable energy systems, such as solar home systems and mini-grids, can provide clean and reliable electricity to rural communities.

KEY WORDS: Economic growth, hydroelectric energy consumption, geo-thermal energy consumption, solar energy consumption, wind power energy consumption.

1.0 INTRODUCTION

As per the IMF Report (2021), global growth saw a deceleration, decreasing from 6.0% in 2021 to 3.2% in 2022 and further to 2.7% in 2023. This growth profile has exhibited lower performance since 2001, with the exception of the global financial crisis and the acute COVID-19 outbreak. Due to the current high inflation rate, the world economy is experiencing a widespread and more severe slowdown than expected. The negative impact on the prognosis is attributed to several factors, including Russia's incursion into Ukraine, the escalating cost of living, the tightening of financial conditions in several regions, and the ongoing COVID-19 outbreak. According to Dorofeev (2021), the presence of persistent and significant economic inequality over an extended period can lead to the emergence of political, social, and economic crises. Investors are at risk and legislative efforts to protect the freedoms of economic participants are hindered by social and political instability. From this perspective, economic inequality can exacerbate a nation's technological sluggishness and even lead to a decline in economic growth. The projected growth rate for the Kenyan economy in 2022 is estimated to be 5.5 percent, with a further increase of over 6.0 percent anticipated in the subsequent years. According to this projection, the ongoing implementation of the "Big Four" projects and the Economic Recovery Strategy will provide support. The implementation of the government's economic stimulus projects is under underway, specifically targeting strategic interventions in several sectors such as agriculture, health, education, drought response, policy, infrastructure, financial inclusion, energy, and environmental preservation.

As per the Budget Review Outlook Paper (2021), the Kenyan economy demonstrated remarkable resilience and recuperation from the COVID-19 shock, owing to its varied composition and the proactive measures taken by the government to bolster firms. In 2021, the economy had a growth of 7.5 percent, following a contraction of only 0.3 percent in the previous year. The economy had a remarkable growth rate of 6.8 percent in the first quarter of 2022, surpassing the 2.7 percent increase observed in the same period of 2021, as the upward trend continued. All sectors of the economy had positive growth during the first quarter of 2022, with the exception of the agriculture sector, which contracted by 0.7 percent compared to a 0.4 percent gain in the first quarter of 2021.

Projections indicate that the economy will see an average growth rate of 5.5 percent in 2022, followed by a growth rate above 6.0 percent in the coming years. According to this projection, the ongoing implementation of the "Big Four" projects and the Economic Recovery Strategy will provide support. The government's economic stimulus programs are currently in the third phase, which encompasses strategic interventions in various sectors such as agriculture, health, education, drought response, policy, infrastructure, financial inclusion, energy, and environmental preservation (Budget Review Outlook Paper, 2021).

In light of the prevailing global climate and energy conditions, Sahlian, Popa, and Creţu (2021) assert that responsible energy and environmental stakeholders have been compelled to undertake unparalleled actions. Coal, oil, gas, and other fossil fuels are naturally occurring resources that have been utilized as energy sources for both human and industrial applications throughout history. The utilization and burning of these resources have led to the generation of greenhouse gas (GHG) emissions. Greenhouse gaseous substances are released by Earth and absorb infrared radiation within specific wavelength ranges. These substances are believed by certain scholars to play a substantial role in the process of global warming and climate change. As stated by The Times of India (2007), global warming refers to the phenomenon of the Earth's temperature increasing due to the accumulation of greenhouse gas emissions, including carbon dioxide (CO_2), and air pollution in the atmosphere. The sun's thermal energy is confined by a layer of hot-house gas, resulting in the warming of the Earth. In the most severe situation, Global Warming would make substantial areas of the world uninhabitable, leading to severe scarcity of food and water, resulting in extensive migration and conflict.

Efforts have been made to endorse policies in the domains of environment and energy with the aim of mitigating the ecological imbalance that has arisen, with the ultimate objective of diminishing greenhouse gas emissions (Sharma, 2019). To achieve these objectives, two separate approaches are to decrease consumption and encourage the use of renewable energy sources. As per the European Commission, which created the European Union Action Plan on "zero air, water, and soil pollution," and which was the primary focus of the European Union's Green Week in 2021, it was imperative to develop a comprehensive program with a long-term perspective that would extend until 2050. The goal of this program is to guarantee a world where environmental pollution is completely eliminated and the health of both humans and natural ecosystems is no longer at risk. Achieving reduced energy use poses significant challenges due to the rapid expansion of the population. The exponential growth of the population has led to a significant increase in the utilization of resources. Conventional resources are finite and restricted to preexisting reserves. Cook, 1976. According to Sharma (2019), there is an increasing disparity between the demands and available resources over successive years. An assessment of the depletion timeframe of conventional resources was conducted to generate predictions based on various consumption and development scenarios. The current assessment and evaluation of global fossil fuel reserves have yielded alarming findings, suggesting that they might potentially be exhausted over a span of approximately 100 years. This projection is based on a scenario wherein consumption is expected to increase throughout the next century, with a scientifically supported estimate of a mere 2% increase.

Energy has a vital role in fostering economic growth and eliminating poverty in the global economy. In 2015, around 1.3 billion individuals, accounting for 15% of the world's population, did not have access to electricity, according to statistics (Mentis, et al, 2017). As stated by Alstone, Gershenson, and Kammen (2015), the implementation of a renewable energy system has the potential to provide electricity to a larger population in a manner that is economically efficient, sustainable, and environmentally friendly. Due to its significant role in fostering sustainable economic growth, environmental economists and policymakers have prioritized the augmentation of renewable energy use as a substitute for conventional energy sources. Hydro, geothermal, wind, sun, wave, tidal, and biomass represent a range of renewable energy technology sources that have the potential to generate energy for both industrial and household purposes. The development and commercialization of renewable energy sources have the potential to stimulate employment and contribute to the reduction of poverty and hunger by generating employment opportunities within the emerging "green" technology sector (Sahlian, Popa, & Creţu, 2021).

According to the study by the Kenya National Bureau of Statistics (KNBS, 2020), Kenyan renewable energy constituted 70% of the total electrical capacity in 2020, surpassing the global average by more than thrice. The transition towards a fully renewable energy source is projected to enhance individuals' accessibility to the domestic power grid, while concurrently reducing industrial costs. A report conducted by the Institute of Economic Affairs revealed that Kenya's economic expansion has exerted heightened pressure on the nation's electrical infrastructure. The annual power demand experienced a growth of 18.9% from 2004 to 2013. The nation's current emphasis lies in the advancement of geothermal and hydroelectric power facilities, in accordance with the Least Cost Power Development Plan. Upon the commissioning of a 280 MW geothermal plant in early 2015, electricity expenses experienced a reduction of up to 30%, contingent upon the client group. Kenya has made substantial expenditures in the field of geothermal energy, a source of electricity that offers cost-effective and environmentally friendly alternatives. The nation achieved the 9th position globally in terms of geothermal power generation capacity, as indicated by the Renewables 2018 Global Status Report, with a capacity of 700 megawatts. Lake Turkana in Kenya is now being constructed as the largest wind power plant in Africa, with more investments being allocated to establish additional wind farms. According to Raturi (2019), over 9 million homes in Kenya already have access to off-grid renewable energy, and this figure is projected to increase in the future.

According to the National Forest Resources Assessment report of 2021, the forest cover in Kenya accounts for a mere 8.83 percent of the country's total land. Large areas of these forest resources are unavailable due to legal or environmental limits, ownership issues, management problems, distances, or infrastructure limitations. The annual fuel wood consumption in the country amounts to 35 million tons, while the annual supply is only 15 million tons, leading to a deficit of 20 million tons. The occurrence of deforestation in both exotic and native vegetation has been exacerbated by a significant scarcity of fuel wood, leading to adverse environmental outcomes including desertification, land degradation, droughts, and malnutrition, among other repercussions. The immediate ramifications of these events have shown in a decelerated pace of economic growth, diminished quality of life, substantial expenditures on healthcare, and scarcity of food, among other adverse and severe consequences (Nel & Cooper, 2009).

In order to foster and sustain sustainable economic growth, it is imperative for Kenya to significantly decrease the utilization of non-renewable energy sources and instead transition towards the adoption of renewable energy sources that are characterized by their cleanliness, safety, and sustainability. The issue around the influence of non-renewable energy on climate change and the perceived lack of economic growth associated with renewable energy has generated considerable debate among different factions (Lorek & Spangenberg, 2014). The primary aim of this study is to illustrate the effects renewable energy sources on economic growth.

2. LITERATURE REVIEW

Ntanos et al. (2018) did a study in European countries that looked at the connection between the consumption of energy derived from renewable energy sources and the economic growth of countries as measured by their GDP per capita. The study focused on 25 European nations. They used a dataset that included data from European countries for the period of time spanning from 2007 to 2016. This suggests that there is a correlation between the dependent variable of GDP and the independents of renewable energy sources (RES) and Non-RES energy consumption, gross fixed capital formation, and labor force in the long-run. The statistical analysis was based on descriptive statistics, cluster analysis, and autoregressive distributed lag (ARDL), and it reveals that all variables are related. In addition, the findings indicate that there is a stronger association between the consumption of RES and the economic growth of nations with a higher GDP than there is between the consumption of RES and the economic growth of nations with a lower GDP.

Ocal and Aslan (2013) conducted research in Turkey to investigate the relationship between the utilization of renewable energy sources and the expansion of the country's economy. In spite of the fact that these studies produced contradictory findings, there was no agreement among the experts on whether or not the utilization of renewable energy sources and the expansion of the economy are connected. The conservation hypothesis was shown to be valid by the research that focused on a specific nation. The Toda–Yamamoto causality tests discovered that economic growth had a negative impact on the consumption of renewable energy, but the ARDL causality tests discovered that the consumption of renewable energy had a negative impact on economic growth.

In a different study, Pao and Fu (2013) used Brazil's annual statistics from 1980 to 2010 to investigate the causal relationships between real GDP and four different types of energy consumption. These types of energy consumption were non-hydroelectric renewable energy consumption (NHREC), total renewable energy consumption (TREC), non-renewable energy consumption (NREC), and the total primary energy consumption (TEC). A long-run equilibrium exists between Brazil's real GDP, labor, capital, and each of the four different categories of consumption, according to the results of a co-integration test. The expansion of the Brazilian economy is inextricably linked to the country's rate of capital formation and labor force growth. While the impact of NHREC/TREC on real output was positive and large, the impact of NREC/TEC was essentially nonexistent. The findings of the vector error correction models indicated that there is a unidirectional causality from NHREC to economic growth, that there is bidirectional causality between economic growth and TREC, and that there is a unidirectional causality from economic growth to either NREC or TEC without any feedback in the long run. According to these findings, Brazil had an energy-independent economy, and economic growth was essential in order to provide the resources required for sustainable development. The development of renewable energy sources would not only contribute to the acceleration of Brazil's economic growth and the slowing of the deterioration of the environment, but it would also open the door to the possibility of playing a leadership role in the international system and enhance the country's ability to compete with more developed nations.

In a separate study, Magazzino, Mele, and Morelli (2021) investigated the connection between the consumption of renewable energy sources and the expansion of the Brazilian economy during the Covid-19 pandemic. The purpose of the study was to determine, through the application of an Artificial Neural Networks (ANNs) experiment in Machine Learning, whether or not an increased reliance on renewable sources of energy could lead to a rise in Brazil's gross domestic product. This acceleration has the potential to mitigate the detrimental impacts of the global Covid-19 pandemic. The empirical findings indicated that an ever-increasing use of renewable energies might be able to support the process of economic expansion. In point of fact, the research revealed, with the help of an ANNs model, how an increase in the consumption of renewable energies triggers an acceleration of GDP in comparison to other energy variables that were taken into consideration in the model.

Using an autoregressive distributed lag model, Cherni and Jouini (2017) conducted a study to investigate the link between CO2 emissions, consumption of renewable energy (RENEC), and economic growth in Tunisia. The authors used the model to analyze the data. The question that guided their research was, "To what extent can renewable energies be used as an alternative to conventional energies?" Conventional energies are well-known for the high levels of greenhouse gas emissions that they produce. In order to investigate the short-run and long-run equilibrium relationships, they carried out Granger causality tests. In addition to this, they attempted to identify the direction of causality between these three variables regarding the economy of Tunisia. According to the findings, over the course of time, the levels of CO2 emissions and RENEC remain unchanged. This is the case for the gross domestic product (GDP). However, the Granger causality tests showed that there was a relationship between RENEC and GDP as well as between RENEC and GDP, but there was no relationship between CO2 emissions and RENEC. This was the case despite the fact that there was a bidirectional relationship between GDP and CO2 emissions. Therefore, an appropriate strategy that promotes the use of renewable energy should be adopted in order to ensure the success of an energy transition project and to reap the benefits of positive impacts on economic growth and the protection of the environment.

Doytch and Narayan (2021) conducted research in which they compared the effects of non-renewable and renewable energy consumption on economic growth. The researchers distinguished between the effects of non-renewable and renewable energy consumption on growth in the manufacturing sector and in the service sector. Doytch and Narayan (2021) constructed their empirical model using an endogenous growth framework with an expanding range of intermediate capital goods integrating both non-renewable and renewable energy inputs. This framework served as the basis for their research. They estimated the effects of non-renewable and renewable energy consumption, differentiated by type of use (industrial, residential, and total final energy consumption), on the growth of manufacturing and services industries while controlling for well-established growth determinants. This allowed them to account for the differences in the effects of non-renewable and renewable energy consumption. They came to the conclusion that using renewable sources of energy helps boost growth in industries that are already experiencing rapid expansion, including the services sector in high-income economies and the manufacturing sector in middle-income economies. In the context of countries with high incomes, non-renewable energy sources function as a supplement to renewable energy sources, whereas in the context of countries with moderate incomes, the two types of energy serve as substitutes for one another. Consumption of energy in industrial settings is the primary cause of the growth impacts. On the basis of their findings, they made the suggestion that an effective policy to incentivize the use of renewable energy should target manufacturing businesses in low-income countries, high-income countries should target the service sector with these incentives, and middle-income countries should focus on manufacturing businesses.

Another study by Saidi and Omri (2020) on the relationship between renewable energy, carbon emission, and economic growth proposed that one of the strategies for meeting the sustainable development goals is to close the gap between carbon emissions and economic development (SDGs). Saidi and Omri (2020) suggested that in today's modern discussion circles, the role that renewable energy can play in re-establishing a healthy balance between the economy and the environment is becoming an increasingly important topic of certain arguments. Therefore, the main purpose of their article was to use both growth and environmental functions to demonstrate the effectiveness of renewable energy in promoting economic growth and mitigating carbon emissions in the case of 15 major renewable energy-consuming countries using both fully modified ordinary least square (FMOLS) and vector error correction model (VECM) estimation techniques. This was accomplished by using growth and environmental functions to demonstrate the effectiveness of renewable energy in promoting economic growth and mitigating carbon emissions in the case of 15 major renewable energy-consuming countries. The findings of the FMOLS approach demonstrated the effectiveness of renewable energy in fostering economic expansion while simultaneously lowering emissions of carbon dioxide. They also discovered through the VECM Granger causality test that there is a bidirectional causality between economic growth and renewable energy in both the short- and long-run for both estimated functions, validating the feedback hypothesis; (ii) there is no causal relationship between CO2 emissions and renewable energy in the long-run, but a bidirectional causality between the two variables is found in the short-run; (iii) there is a bidirectional relationship between economic growth and CO2 emissions in the short run and in the long run.

The results presented in a top-cited article in the journal by Inglesi-Lotz (2016) were replicated and extended in a study by Dogan, Altinoz, Madaleno, and Taskin (2020). This article examined the impact of renewable energy consumption on economic growth for the OECD countries by applying the ordinary least squares with fixed effect estimator on the data from 1990 to 2010. The study began by producing empirical results, which were then compared to those that were presented in the initial paper by using the same data and procedures that were used in the original study. After that, it applied a series of new econometric methodologies to the same data in order to address the heterogeneity that existed in the renewable energy and economic growth across the group of countries that were being examined. The panel quantile regression estimation showed that the effect of renewable energy consumption on economic growth is positive for lower and low-middle quantiles. However, its effect becomes negative for middle, high-middle, and higher quantiles when renewable energy consumption is proxied by the absolute value. In addition, a negative impact of renewable energy on economic growth is observed in almost all quantiles when it is proxied by the share of renewable energy consumption to total energy consumption. This finding contradicts the hypothesis that renewable energy will have a positive impact on economic growth. These results are a significant departure from the ones obtained in the first version.

Bhattacharya, Paramati, Ozturk, and Bhattacharya (2016) conducted a study to explore the effects of consumption of renewable energy on the economic growth of key renewable energy consuming countries around the world. They selected the top 38 countries in terms of consumption of renewable energy between the years 1991 and 2012, using the Renewable Energy Country Attractiveness Index that was developed by Ernst & Young Global Limited. This allowed them to explain the growth process that occurred between those two time periods. Their findings, which were obtained through the use of panel estimate techniques, revealed cross-sectional dependence as well as heterogeneity among the countries. They found evidence of long-run dynamics between economic growth and traditional as well as energy-related inputs, and they validated those trends. The findings from the long-run output elasticities suggested that the consumption of renewable energy had a significant positive influence on the economic production for 57 percent of the countries that were selected. They also carried out time-series analyses of long-run production elasticities to ensure the accuracy of their findings. According to their results, the majority of these countries' governments, energy planners, international cooperation agencies, and other connected authorities need to work together to increase investment in renewable energy in order to achieve low carbon growth.

Thiam (2011) asserts that the desire to increase access to energy sources is still a major driving force behind attempts to combat poverty in rural parts of developing countries in Africa. The availability of modern energy makes it simpler to enhance human living standards and diverse sector production. It also makes a contribution by decreasing the time spent harvesting biomass, primarily by women and children. As a result, it might present a chance for women's emancipation and for children's educational levels to rise. Any approach to help people escape poverty must include access to renewable energy sources (Mulugetta, Hagan, & Kammen, 2019).

In order to promote and maintain sustainable economic growth in Kenya, there is need for a huge reduction on the dependency on non-renewable energy consumption to dependency on renewable energy that is clean, safe, and sustainable. The bone of contention among different stakeholders has been that non-renewable energy does have implications on the climate change and that renewable energy does not contribute to the economic growth of a country (Lorek & Spangenberg, 2014). The aim of this study was to show how energy consumption from renewable sources contribute to the economic growth and therefore a need for more investment in this area.

A study done by Chen, Pinar & Stengos (2020) used threshold model to analyze the 1995–2015 period's 103-country sample in order to determine the causal relationship between the use of renewable energy and economic development. They discovered that the amount of renewable energy consumed determines the relationship between economic growth and the consumption of renewable energy. They found that, if and only if emerging nations or non-OECD countries reach a particular level of renewable energy consumption, the impact of such consumption on economic growth is favorable and significant. Renewable energy use, however, has a detrimental impact on economic growth if emerging nations use it at levels below a predetermined threshold.

However, they also discovered that the use of renewable energy had a favorable and considerable impact on economic growth in OECD countries but no discernible impact on economic growth in developed nations. According to their paper's findings, developing nations must consume more renewable energy than a specific amount in order to experience positive economic growth because of their investments in renewable energy.

A non-parametric modeling technique was used by Ivanovski, Hailemariam, and Smyth (2021) to investigate the time-varying effects of renewable and non-renewable energy consumption on economic growth. They applied the local linear dummy variable estimation (LLDVE) approach, a specialized nonparametric technique, on OECD and non-OECD panels for the years 1990 to 2015. The LLDVE method has the advantage that it does not make any assumptions about functional form and, as a result, was better able to approximate the non-linear relationship, even though previous studies using parametric models had acknowledged the existence of non-linearities and instability in the relationship between the consumption of renewable (and non-renewable) energy and economic growth. According to their estimations, non-renewable energy consumption has a positive and considerable influence on economic growth across OECD countries, with the coefficient function showing a long-term rising trend. However, during the majority of the study period, the effect of renewable energy consumption on economic growth in these nations was statistically equivalent to zero. Consumption of both renewable and non-renewable energy contributes to economic growth in non-OECD nations, indicating that despite technical limitations, developing nations may be crucial in the shift to renewable energy. However, they also discovered that the use of renewable energy had a favorable and considerable impact on economic growth in OECD countries but no discernible impact on economic growth in developed nations. According to the research presented in their study, developing nations must consume enough renewable energy to exceed a particular threshold in order to have a positive return on their investment in renewable energy.

Baz et al. (2021) assert that exploiting energy resources helps achieve economic goals, environmental transformation, and energy demand fulfillment through the creation of clean energy and new technology. But actual research must be done on the methods for achieving these connected goals and sustainable development. To this goal, we used Pakistani time series data from 1980 to 2017 to analyze the relationship between fossil fuel, renewable energy, and economic growth. This study establishes the asymmetric effect of one variable on the others by using a non-linear autoregressive distributed lag and asymmetric causality techniques. The investigation's findings supported the existence of asymmetric and nonlinear co-integration between the variable pairs. Positive shocks to economic development and usage of renewable energy were found to have an asymmetric feedback causation relationship. While a symmetric bidirectional hypothesis was found between the consumption of fossil fuels and economic growth, the asymmetric causality test revealed that positive and negative shocks in the two variables had a neutral effect. Finally, it was established that there is an asymmetrically unidirectional causal relationship between foreign direct investment and economic growth. In the long run, our findings point to the importance of installing innovative technologies and renewable energy sources in order to achieve sustainable economic growth without endangering the environment's integrity and ecosystem.

3. RESEARCH METHODOLOGY

3.1 Research Design

This study utilized an explanatory research design to analyze the relationships between the variables, their causes, and effects. This study aimed to establish the causal relationship between variables related to renewable energy consumption and economic growth in Kenya.

3.2 Data Type and Source

This research study made use of a secondary type of data. Hydroelectric energy consumption, geo-thermal energy consumption, solar energy consumption and wind energy consumption were used in data analysis. The study data was extracted from Kenya National Bureau of Statistics (KNBS), World bank data base and Energy regulatory commission. The Auto-regressive Distributed Lag model was used for analysis and the project's study period spanned from 1986 to 2022.

3.3 Measurement of variables

Variable	Definition	Measurement
Economic Growth (EG)	It is an increase of the overall capacity to create goods and services during a specific period of time as compared to the previous period (Stern, 2004).	Gross Domestic Product (GDP) in dollars
Hydroelectric Energy Consumption (HEC)	It is a renewable energy source that uses the movement of water to produce electricity (Mohtasham, 2015).	Megawatt-hours (MWh)

Solar Energy Consumption (SEC)	Energy Consumption from the sun's electromagnetic radiation which is renewable and non-exhaustible (Panneerselvam, Subramaniam & Perumal, 2014).	Kilowatt hours
Geothermal Energy Consumption (GEC)	Energy consumption from transforming heat energy from the core of the Earth into usable energy (Hasnain, 1998).	Kilowatt hours
Wind Power Energy Consumption (WEC)	is the consumption of energy derived from the process of turning the movement of air into mechanical or electrical power (Heier, 2014).	Kilowatt hours

3.4 Model specification

The autoregressive distributed lag (ARDL) time series model was utilized in order to do the estimations for the empirical models described above. Because the model described above contains lags in both the dependent and independent variables, the autoregressive distributed lag (ARDL) time series model was used to analyze the data. The Augmented Dickey-Fuller Unit (ADF) Roots Test was utilized in order to evaluate the unit tests of the model that has been specified. In addition, the model presupposes that there is neither heteroscedasticity nor multicollinearity, and that the error term follows a normal distribution. For the purposes of estimating the model and analyzing the data, this study made use of the E-views statistical package.

This research used the following empirical equations to realize its objectives.

Economic Growth ***EG*****,** Hydro-electric energy consumption HEC_t, Solar energy consumption SEC_t, Wind power energy consumption WPC_t, and Geo-thermal energy consumption GEC_t can be incorporated in the model using the following functional model:

$$EG_t = \beta_0 + \beta_1 HEC_t + \beta_2 SEC_t + \beta_3 WPC_t + \beta_4 GEC_t + e_t \quad (1)$$

Where:

EG_t is the Economic growth in period t

β_0 is the constant

HEC_t is the Hydro-electric energy consumption in period t

SEC_t is the Solar energy consumption in period t

WPC_t Wind power energy consumption in period t

GEC_t Geo-thermal energy consumption in period t

β_1 β_2, β_3, β_4 are the parameters of the model

e_t is the random error term

Error Correction Model (ECM) shows long run relationships between the dependent variables and the independent variables. This is done by performing the first difference of the ADL model.

yt = Φ1yt-1 + … + Φpyt-p + θ0xt + θ1xt-1 …+ q1xt-p +u1t (2)

xt = Φ2xt-1 + … + Φpxt-p + θ0yt + θ1yt-1 …+ q1yt-p + u2t (3)

t =1,2,…T μt ~ iid(0, δ2).

$$\Delta EG_t = \beta_0 + \beta_1 \Delta EG_{t-1} + \beta_2 \Delta HEC_{t-1} + \beta_3 \Delta SEC_{t-1} + \beta_4 \Delta GEC_{t-1} + \beta_5 \Delta WPC_{t-1} +$$

$$\beta_6 HEC_{t-1} + \beta_7 SEC_{t-1} + \beta_8 GEC_{t-1} + \beta_9 WPC_{t-1} + \varepsilon_t \quad (4)$$

Where

$\Delta EG_t = EG_{t-1} - EG_{t-2}$

$\Delta EG_{t-1} = EG_{t-1} - EG_{t-2}$

$\Delta HEC_{t-1} = HEC_{t-1} - HEC_{t-2}$

$\Delta SEC_{t-1} = SEC_{t-1} - SEC_{t-2}$

$\Delta GEC_{t-1} = GEC_{t-1} - GEC_{t-2}$

EG_t is the Economic growth in period t

EG_{t-1} is the Economic growth in period t-1

β_0 is the constant

HEC_t is the Hydro-electric energy consumption in period t

HEC_{t-1} is the Hydro-electric energy consumption in period t-1

SEC_t is the Solar energy consumption in period t
$SEC_{t-1}$is the Solar energy consumption in period t-1
WPC_t Wind power energy consumption in period t
WPC_{t-1} Wind power energy consumption in period t-1
GEC_t Geo-thermal energy consumption in period t
GEC_{t-1} Geo-thermal energy consumption in period t-1
β_1 β_2, β_3 β_4, β_5 β_6, β_7 β_8 and β_9 are the parameters of the model
e_t is the random error term

4.0 DATA ANALYSIS, RESULTS AND DISCUSSION

4.1. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Economic Growth	37	3.72E+10	3.45E+10	5.75E+09	1.13E+11
Geo-thermal Consumption	37	6922.000	7414.648	1183.000	25723.00
Hydroelectric Energy Consumption	37	9257.189	4722.047	1090.000	18726.00
Solar Energy Consumption	37	37417.46	45593.18	3353.000	157872.0
Wind power consumption	37	12472.54	15197.71	1118.0	52624.0

This indicates that the average economic growth over the observed period is $37.2 billion. However, the data points are quite spread out, as evidenced by the high standard deviation of $34.5 billion. The lowest recorded economic growth is $5.75 billion, while the highest is $113 billion. The graph below represents the economic growth values for each year from 1986 to 2022. In the mid to late 1980s, the economic growth values were relatively modest, ranging from $7.24 billion in 1986 to $8.36 billion in 1988. However, there was a slight decline in 1989 to $8.28 billion before rebounding to $8.57 billion in 1990. From 1991 to 1994, there was a period of fluctuation in economic growth, with values ranging from $5.75 billion in 1993 to $9.04 billion in 1995. Notably, 1996 marked a significant increase in economic growth, reaching $12.05 billion, followed by further growth in the subsequent years. The late 1990s saw a relatively stable but moderate growth, with economic growth values ranging from $12.90 billion in 1999 to $14.09 billion in 1998. However, in the early 2000s, there was a slight decline, with the economic growth values falling to $12.71 billion in 2000. This decline was followed by a gradual recovery, reaching $14.90 billion in 2003. From 2004 to 2007, there was a period of robust economic growth, with values increasing steadily each year. Notably, the economic growth almost doubled between 2005 and 2007, rising from $18.74 billion to $31.96 billion. The growth surpassed $70 billion in 2015 and reached a staggering $113.42 billion in 2022. Notably, the economic growth crossed the $100 billion mark in 2019 and has consistently remained above this threshold since then. Overall, the data reflects a general trend of increasing economic growth over the observed period, with notable fluctuations and significant growth spikes in specific years.

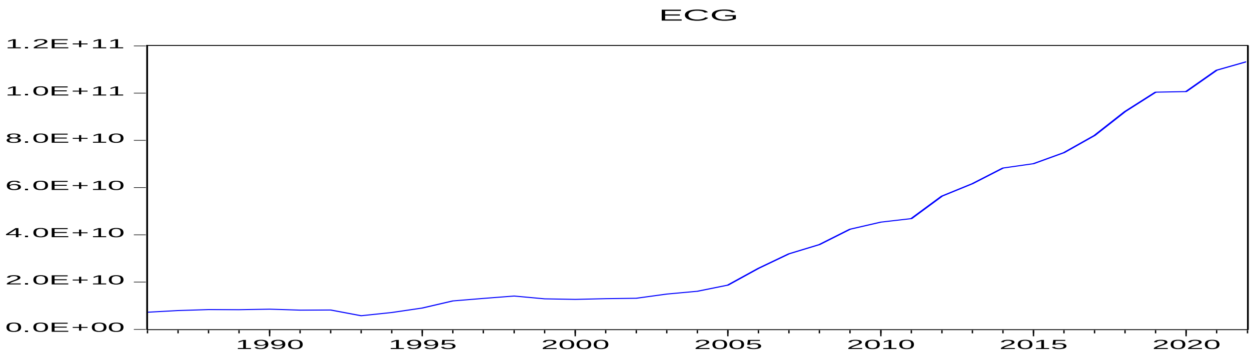

Figure 4. 1: Economic growth graphical representation

On average, the geo-thermal consumption is approximately 6,922 units. The values vary considerably, as indicated by the standard deviation of 7,415. The lowest consumption recorded is 1,183 units, while the highest is 25,723 units. The graph below represent the geo-thermal energy consumption values for each year from 1986 to 2022. In the earlier years, from 1986 to 1992, the geo-thermal energy consumption values gradually decreased. They ranged from 6,408 units in 1986 to 2,560 units in 1992, indicating a declining trend during this period. From 1993 to 2000, the consumption values remained relatively low, with fluctuations but no clear trend. The consumption ranged from 1,872 units in 1993 to 3,098 units in 2000. Starting in 2001, there was a slight increase in geo-thermal energy consumption, with values ranging from 3,157 units to 3,216 units. However, the consumption remained relatively stable during this period. From 2004 to 2009, the consumption values decreased significantly, reaching a low of 1,382 units in 2008. However, in 2009, there was a substantial increase, with consumption rising to 3,741 units.

From 2010 to 2012, the consumption remained relatively low, fluctuating around the 2,000 to 2,300 units range. Starting in 2013, there was a significant increase in geo-thermal energy consumption. The values surged from 2,224 units in 2013 to 25,723 units in 2022. This upward trend indicates a substantial growth in the utilization of geo-thermal energy over recent years. Overall, the data reflects a mix of declining, stable, and increasing geo-thermal energy consumption patterns over the observed period. However, from 2013 onwards, there has been a remarkable and consistent growth in consumption, suggesting an increasing focus on utilizing geo-thermal energy as a renewable energy source.

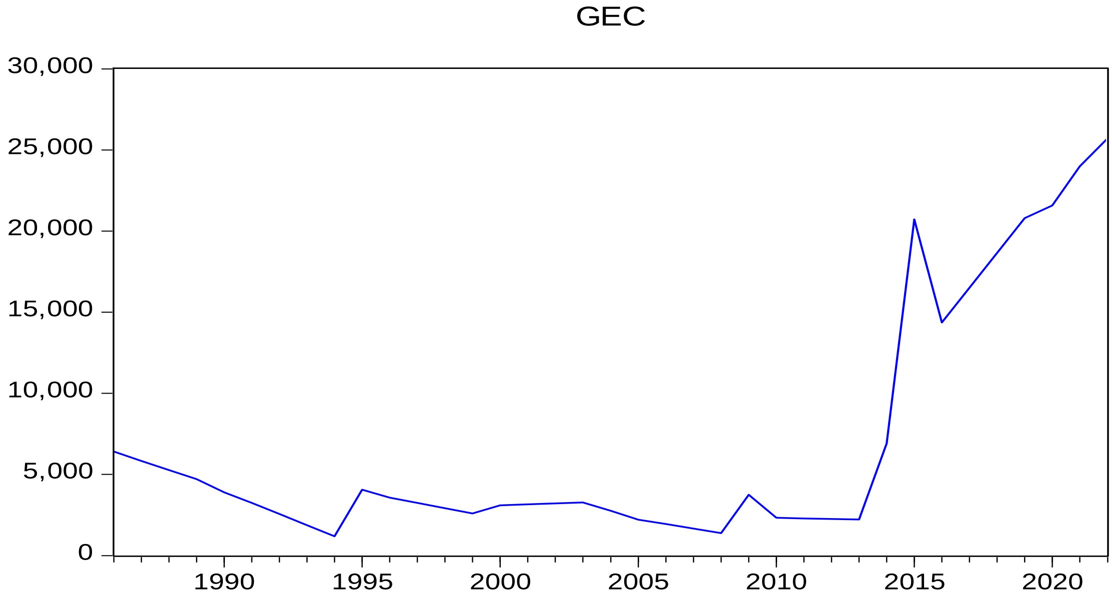

Figure 4.2: Geo-thermal energy consumption graphical representation

The average solar energy consumption is approximately 37,417.46 units. The data points have a high degree of variability, as indicated by the large standard deviation of 45,593.18. The lowest recorded consumption is 3,353 units, while the highest is 157,872 units. The provided graph below represents the solar energy consumption values for each year from 1986 to 2022. In the earlier years, from 1986 to 1995, the solar energy consumption values gradually increased. They ranged from 3,353 units in 1986 to 14,158 units in 1994, indicating a steady growth in solar energy utilization during this period. From 1996 to 2000, the consumption values remained relatively stable, with some fluctuations. The consumption ranged from 11,958 units in 1996 to 16,467 units in 1999.

Starting in 2001, there was a slight decrease in solar energy consumption, with values ranging from 15,364 units to 17,943 units. However, the consumption remained relatively steady during this period. From 2004 to 2008, there was a significant decline in solar energy consumption. The values dropped from 11,583 units in 2004 to 16,930 units in 2008. In 2009, there was a substantial increase in solar energy consumption, with consumption rising to 27,054 units. This surge in consumption marked a turning point, leading to significant growth in the subsequent years. From 2010 to 2022, the consumption of solar energy experienced remarkable and consistent growth. The values surged from 20,056 units in 2010 to 157,872 units in 2022. This upward trend indicates a substantial increase in the utilization of solar energy as a renewable energy source over the past decade. Overall, the data reflects a mix of steady, declining, and significant growth patterns in solar energy consumption over the observed period. However, starting in 2009, there has been a remarkable and consistent growth in consumption, suggesting an increasing focus on harnessing solar energy and a shift towards renewable energy sources.

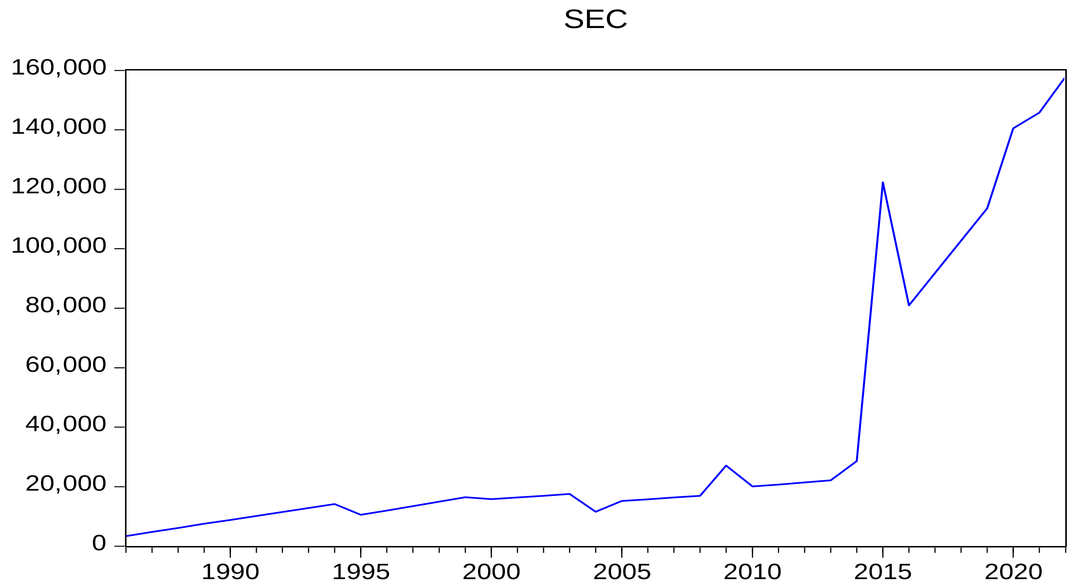

Figure 4. 3: Solar energy consumption graphical representation

The average hydroelectric energy consumption is approximately 9,257 units. The data points have a moderate amount of variability, with a standard deviation of 4,722. The lowest consumption observed is 1,090 units, while the highest is 18,726 units. The provided graph below represents the hydroelectric energy consumption values for each year from 1986 to 2022. In the earlier years, from 1986 to 1996, the hydroelectric energy consumption values gradually increased. They ranged from 1,090 units in 1986 to 5,120 units in 1996, indicating a steady growth in hydroelectric energy utilization during this period. From 1997 to 2001, the consumption values remained relatively stable, with some fluctuations. The consumption ranged from 5,522 units in 1997 to 6,731 units in 2000. Starting in 2002, there was a slight decrease in hydroelectric energy consumption, with values ranging from 5,624 units to 6,024 units. However, the consumption remained relatively steady during this period. From 2004 to 2008, there was a significant decline in hydroelectric energy consumption. The values dropped from 4,770 units in 2004 to 1,497 units in 2008. In 2009, there was a substantial increase in hydroelectric energy consumption, with consumption rising to 10,940 units. This surge in consumption marked a turning point, leading to significant growth in the subsequent years.

From 2010 to 2014, the consumption of hydroelectric energy experienced remarkable and consistent growth. The values surged from 6,237 units in 2010 to 11,606 units in 2014, indicating a significant increase in the utilization of hydroelectric energy as a renewable energy source. From 2015 to 2022, the consumption of hydroelectric energy remained relatively stable, with values ranging from 10,845 units to 14,443 units. Although there were minor fluctuations, the consumption did not exhibit a clear increasing or decreasing trend during this period. Overall, the data reflects a mix of steady growth, declining trends, and stable consumption patterns in hydroelectric energy utilization over the observed period. However, starting in 2009, there was a significant increase in consumption, highlighting the importance of hydroelectric power in the energy mix and its role as a renewable energy source.

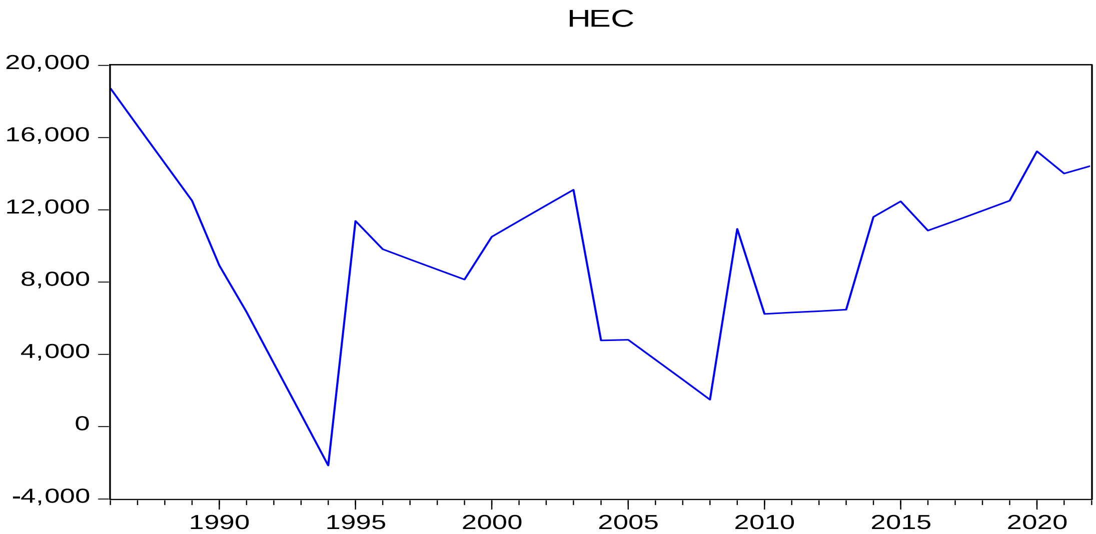

Figure 4. 4: Hydro-electric energy consumption graphical representation

Average, the wind power consumption is approximately 12,472.54 units. The data points have a significant amount of variability, as indicated by the standard deviation of 15,197.71. The lowest consumption recorded is 1,118 units, while the highest is 52,624 units. The provided graph represents the wind power energy consumption values for each year from 1986 to 2022. In the earlier years, from 1986 to 1996, the wind power energy consumption values gradually increased. They ranged from 1,118 units in 1986 to 3,986 units in 1996, indicating a steady growth in wind power energy utilization during this period. From 1997 to 2001, the consumption values continued to rise, with some fluctuations. The consumption ranged from 4,487 units in 1997 to 5,455 units in 2001. Starting in 2002, there was a slight decrease in wind power energy consumption, with values ranging from 5,648 units to 5,841 units. However, the consumption remained relatively stable during this period.

From 2004 to 2008, there was a significant decline in wind power energy consumption. The values dropped from 3,861 units in 2004 to 5,643 units in 2008. In 2009, there was a substantial increase in wind power energy consumption, with consumption rising to 9,018 units. This marked a turning point, leading to significant growth in the subsequent years. From 2010 to 2014, the consumption of wind power energy experienced remarkable and consistent growth. The values surged from 6,685 units in 2010 to 9,531 units in 2014, indicating a substantial increase in the utilization of wind power energy as a renewable energy source. From 2015 to 2022, the consumption of wind power energy continued to increase significantly. The values ranged from 26,986 units to 52,624 units. This period reflects a remarkable growth in wind power energy utilization, with 2022 reaching the highest consumption level observed. Overall, the data demonstrates a clear upward trend in wind power energy consumption over the observed period. The utilization of wind power has steadily increased, indicating its growing importance in the energy sector as a sustainable and renewable source of power.

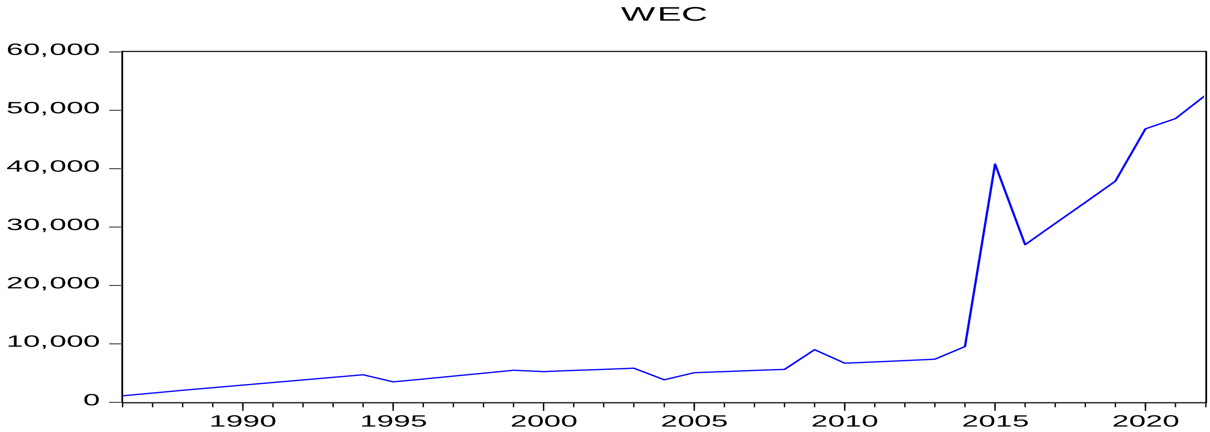

Figure 4. 5: Wind power energy consumption graphical representation

4.2 Normality Test

The Jarque-Bera test yielded a p-value of.3818, which is significantly higher than the significance level of 0.05. It indicates that the result is not statistically significant, that the null hypothesis cannot be rejected, and that the null hypothesis states that the residuals follow a normal distribution.

Test	Variable	Observation	Prob>z
Jacque Bera	Residuals	37	0.7491

Source (Field data, 2023)

4.3 Autocorrelation Test

Breusch-Godfrey test for autocorrelation was used to check for autocorrelation. The results presented in table below show that the *p-values* is 0.9798 >0.05. Therefore, the test's null hypothesis that there is no first order correlation cannot be rejected.

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.020465	Prob. F(2,9)	0.9798
Obs*R-squared	0.149401	Prob. Chi-Square(2)	0.9280

Source (Field data, 2023)

4.4 Heteroskedasticity Test

The results of this test, shown in below, indicate that the residuals of the model are homoscedastic. This conclusion is supported by the p values corresponding to the chi-square test statistics of 0.7896, which are greater than the 5% level of significance (0.05).

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.674220	Prob. F(21,11)	0.7896
Obs*R-squared	18.57154	Prob. Chi-Square(21)	0.6126
Scaled explained SS	2.737412	Prob. Chi-Square(21)	1.0000

Source (Field data, 2023)

4.5 Multi-collinearity Test

Multicollinearity implies that that two or more of the predictor variables are highly correlated. The study used the Variance inflation factor (VIF) and the correlation matrix to check for the presence or absence of multicollinearity. Multicollinearity is present if the VIF value is higher than 10 (Gujarati, 2012) or the pairwise correlation coefficients are greater than 0.8. The table below indicates that the VIF values range between 3.05 and 1.12; which, are less than 10, implying the research variables do not suffer from multicollinearity.

Variable	VIF	1/VIF
Economic growth	1.89	0.529100
Hydro-electric energy consumption	1.94	0.515464
Solar energy-electric energy consumption	3.05	0.327869
Wind power energy consumption	1.29	0.775194
Geo-thermal energy consumption	1.21	0.829834
Mean VIF	1.876	

Source (Field data, 2023)

4.6 Stationarity Test

Source (Field data, 2023)

From the results of the table above, the null hypothesis of unit root of economic growth, hydro-electric energy consumption, solar energy consumption, wind power energy consumption and geo-thermal energy consumption is rejected at 5 percent level of significance. This suggests that economic growth, hydro-electric energy consumption, solar energy consumption, wind power energy consumption and geo-thermal energy consumption do not have a unit root which means they are stationary.

Variable	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Economic growth	-5.523	-3.675	-2.969	-2.617
Hydro-electric energy consumption	-0.327	-3.675	-2.969	-2.617
Solar energy-electric energy consumption	-4.485	-3.675	-2.969	-2.617
Wind power energy consumption	-4.239	-3.675	-2.969	-2.617
Geo-thermal energy consumption	-3.634	-3.675	-2.969	-2.617

4.7 Co-integration Test

Table below shows that the null hypothesis of no level relationship was accepted. This is because the F statistics of 3.0649 was less than the 5 percent critical value of the upper bound (I_1) of 4.01. This result suggests that there was no level relationship among variables and therefore a short run relationship existed. The outcome of these results meant that the model would be estimated using the ARDL.

Table 4. 1: Co-integration Test Results

ARDL Bounds Test
Date: 07/15/23 Time: 00:13
Sample: 1990- 2022
Included observations: 33
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	3.064910	4

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Test Equation:
Dependent Variable: D(ECG)
Method: Least Squares
Date: 07/15/23 Time: 00:13
Sample: 1990 2022
Included observations: 33

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ECG(-1))	-0.512478	0.341036	-1.502712	0.1588
D(ECG(-2))	-0.069150	0.251908	-0.274505	0.7884
D(GEC)	1161528.	382877.6	3.033679	0.0104
D(GEC(-1))	1472994.	648223.3	2.272355	0.0423
D(GEC(-2))	1572053.	615895.7	2.552466	0.0254
D(GEC(-3))	1286980.	580543.8	2.216853	0.0467
D(HEC)	-776373.1	304845.3	-2.546778	0.0256
D(HEC(-1))	322705.1	412754.1	0.781834	0.4495
D(HEC(-2))	-445412.4	334093.3	-1.333198	0.2072
D(HEC(-3))	-247386.7	302337.6	-0.818247	0.4292
D(SEC)	-5.29E+08	5.08E+08	-1.040851	0.3185
D(SEC(-1))	-8.44E+08	5.02E+08	-1.681940	0.1184
D(WEC)	1.59E+09	1.53E+09	1.040512	0.3186
D(WEC(-1))	2.53E+09	1.51E+09	1.681309	0.1185
D(WEC(-2))	-851677.5	375440.6	-2.268475	0.0426
D(WEC(-3))	-550949.4	300693.9	-1.832260	0.0918

C	9.58E+09	2.97E+09	3.226388	0.0073
GEC(-1)	-548411.5	450205.4	-1.218136	0.2466
HEC(-1)	-1910885.	676321.2	-2.825411	0.0153
SEC(-1)	163411.5	111801.6	1.461621	0.1695
ECG(-1)	0.196477	0.082788	2.373257	0.0352

R-squared	0.869226	Mean dependent var	3.19E+09
Adjusted R-squared	0.651269	S.D. dependent var	3.37E+09
S.E. of regression	1.99E+09	Akaike info criterion	45.92164
Sum squared resid	4.75E+19	Schwarz criterion	46.87397
Log likelihood	-736.7071	Hannan-Quinn criter.	46.24207
F-statistic	3.988070	Durbin-Watson stat	2.026332
Prob(F-statistic)	0.008696		

Source (Field data, 2023)

4.8 Parameter Stability Test

In order to assess whether or not the model's variables can be predicted with accuracy, the CUSUM test was carried out. Because of this, it was possible to watch how the coefficients that were being estimated changed over time, even as the sample size of the data that was being used to make the estimates got greater. This was true even though the estimates were being generated using a higher percentage of the whole data set. The estimated coefficients have two error zones on either side of them, and these error zones are determined by the standard deviation. When new information is added to an equation that is being used for estimation, it is a clear sign that the system is unstable if there is a large variance in the coefficient. This is because equations are being utilized to make estimates. In the event that there is a substantial disparity between the various estimations of the coefficient, then. If it is discovered that the blue line is positioned somewhere other than between the two red lines, this is an evident indication that there is not enough stability. Figures 4.6 and 4.7, respectively, display the results of the CUSUM and CUSUM of squares calculations that were performed. Both plots illustrated the fact that the blue lines may be found inside the red lines. This suggests that the variables that were used in the model were stable over the course of the investigation. Figure 4.6 and Figure 4.7 and depicts a variety of graphs illustrating the residuals of the variables that were used in the model. These graphs were used in the model. The residuals of the variables move in a cyclical pattern around the mean value. This satisfies the criterion that the mean of the residuals be zero, which is a prerequisite for the normality assumption. Having the mean of the residuals be zero is required.

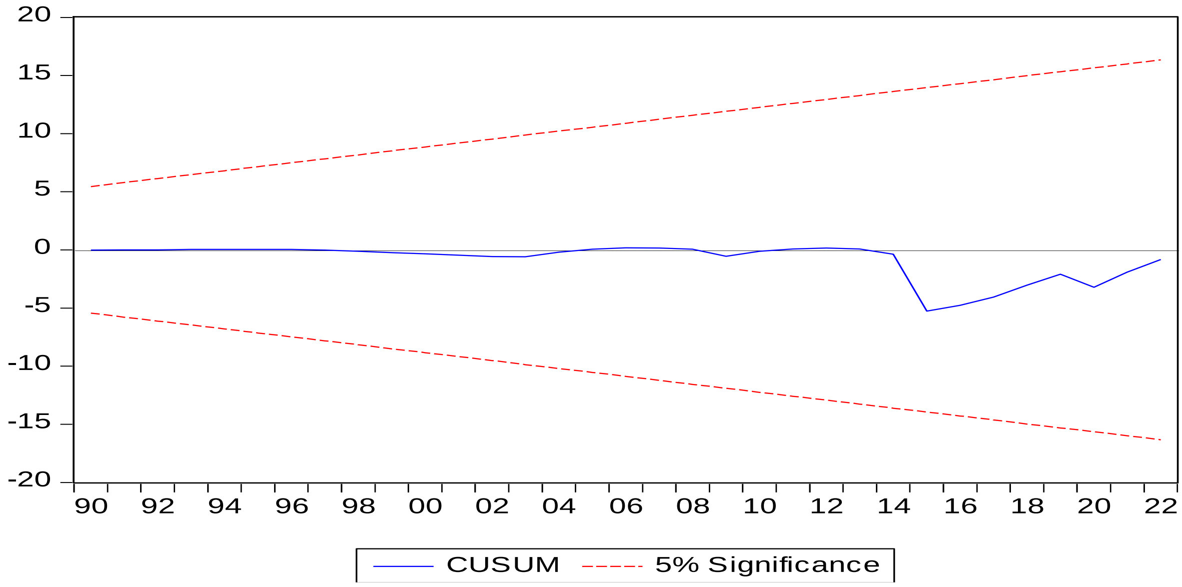

Figure 4. 6: CUSUM Graphical Representation

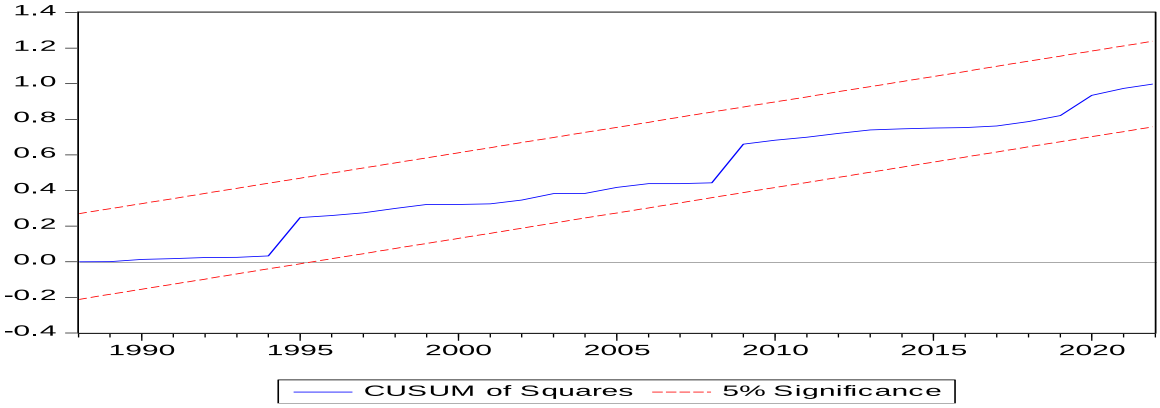

Figure 4. 7: CUSUM of Squares Graphical Representation

4.9 Discussion of results

Dependent Variable: ECG
Method: ARDL
Date: 06/14/23 Time: 23:13
Sample (adjusted): 1990 2022
Included observations: 33 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): GEC HEC SEC WDEC
Fixed regressors: C
Number of models evalulated: 2500
Selected Model: ARDL(4, 3, 2, 4, 4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
ECG(-1)	0.319811	0.186742	1.712579	0.1148
ECG(-2)	0.705481	0.248862	2.834829	0.0162
ECG(-3)	0.634586	0.286303	2.216486	0.0487
ECG(-4)	-0.272265	0.227734	-1.195539	0.2570
GEC	2183823.	531705.1	4.107207	0.0017
GEC(-1)	872423.2	646500.8	1.349454	0.2043
GEC(-2)	-1742437.	549655.3	-3.170055	0.0089
GEC(-3)	-532421.9	522983.1	-1.018048	0.3305
HEC	1431790.	308874.7	-4.635505	0.0007
HEC(-1)	-1167817.	289988.7	-4.027111	0.0020
HEC(-2)	-584743.8	278047.3	-2.103037	0.0593
SEC	362143.6	268514.4	1.348693	0.2045
SEC(-1)	103991.5	340087.3	0.305779	0.7655
SEC(-2)	-566442.3	290218.6	-1.951778	0.0769
SEC(-3)	-89425.07	228582.0	-0.391217	0.7031
SEC(-4)	1159799.	233205.4	4.973292	0.0004
WDEC	3.28E-05	1.38E-05	2.375073	0.0368
WDEC(-1)	-6.57E-06	1.78E-05	-0.369738	0.7186
WDEC(-2)	4.14E-05	1.48E-05	2.800044	0.0173
WDEC(-3)	1.62E-05	1.21E-05	1.335284	0.2088
WDEC(-4)	-4.53E-05	9.57E-06	-4.727535	0.0006
C	1.13E+09	2.05E+09	0.550779	0.5928
R-squared	0.999434	Mean dependent var		4.08E+10

Adjusted R-squared	0.998354	S.D. dependent var	3.49E+10
S.E. of regression	1.42E+09	Akaike info criterion	45.21681
Sum squared resid	2.21E+19	Schwarz criterion	46.21448
Log likelihood	-724.0773	Hannan-Quinn criter.	45.55249
F-statistic	925.0511	Durbin-Watson stat	2.056090
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model

Source (Field data, 2023)

Hypothesis (H_{01}) stated that; *hydro-electric energy consumption has no significant effect on economic growth in Kenya.* As illustrated in Table 4.10, the regression output shows that hydro-electric energy consumption had a significantly positive effect on economic growth *($\beta 1$ =143.1797 and $\rho<0.05$)*; thus, H_{01} was rejected. The findings of this study was in agreement with another study done by Odhiambo, (2010); Ogundipe, (2013) and Gyimah, et al., (2022).

The fact that use of hydroelectric energy is positively and significantly correlated with economic growth draws attention to the numerous economic, environmental, and social benefits that are involved with the use of hydropower. Utilizing the potential of hydroelectric energy may play a crucial role in ensuring energy security, job creation, and environmental sustainability, which are all important factors in the pursuit of sustainable economic growth by nations. To maximize the positive impact on economic growth while simultaneously avoiding any negative effects on the environment and society, policymakers should give top priority to investments in hydroelectric infrastructure and assure the appropriate and sustainable management of water resources.

Hypothesis (H_{02}) stated that; *solar energy consumption has no significant effect on economic growth in Kenya.* As illustrated in Table 4.10, the regression output shows that solar energy consumption had an insignificant positive effect on economic growth *($\beta 2$ =3621.436 and $\rho<0.05$)*; thus, H_{02} was accepted. . The findings of this study was in disagreement with another study done by Bhuiyan et al., (2022), Shakouri & Khoshnevis Yazdi, 2017) and Chen, Pinar & Stengos, (2020).

Solar energy encourages sustainability and environmental consciousness, both of which are congruent with the increasing emphasis placed on renewable energy sources on a worldwide scale. As nations make the switch to solar energy, they lessen their reliance on fossil fuels and cut their carbon emissions, which results in a cleaner environment and a healthier populace. This move toward more sustainable energy sources encourages innovation, research, and development in the solar energy sector, which results in the creation of new job opportunities and contributes to the expansion of the economy. In addition, solar energy offers a stable and cost-effective source of electricity, which helps to lower overall energy expenses for both commercial and residential properties. Manufacturing, agricultural, and service industries all benefit from increased productivity and efficiency, which in turn contributes to overall economic expansion. The availability of energy that is both affordable and environmentally friendly is essential to achieving this goal. In addition, investments in solar energy infrastructure and technology stimulate economic activity, which in turn attracts foreign direct investment and promotes economic growth. In general, the positive association between the consumption of solar energy and economic growth reflects the various economic, environmental, and social benefits connected with the use of renewable energy sources.

Hypothesis (H_{03}) stated that; *wind power energy consumption has no significant effect on economic growth in Kenya.* As illustrated in Table 4.10, the regression output shows that wind power energy consumption had a significantly positive effect on economic growth *($\beta 3$ =0.000033 and $\rho<0.05$)*; thus, H_{03} was rejected. The findings of this study was in disagreement with another study done by Xia & Song, (2017), Yu & Qu, (2010) and Dincer, (2011).

Wind power is an example of a renewable and sustainable energy source that can help mitigate the negative effects of climate change while also reducing the emissions of greenhouse gases. The implementation of wind power encourages investments in the infrastructure and technology of renewable energy sources, which in turn generates job opportunities and propels economic growth in nations that are in the process of transitioning to greener energy systems. Wind farm construction, installation, and maintenance require trained labor and support sectors, both of which stimulate economic activity and local development. In addition, wind power offers a reliable and affordable source of electricity, which lowers the overall cost of energy for both commercial and residential customers. This results in increased levels of both productivity and competitiveness. In addition, the expansion of the wind power industry encourages investments and stimulates innovation in industries that are connected to it, such as the production of wind turbines and research and development, both of which further contribute to the expansion of the economy. The fact that increased use of wind power is positively correlated with increased economic activity demonstrates how renewable energy sources have the ability to foster both equitable and environmentally responsible development.

Effect of Renewable Energy Consumption on Economic Growth in Kenya

Hypothesis (H_{04}) stated that; *geo-thermal energy consumption has no significant effect on economic growth in Kenya.* As illustrated in Table 4.10, the regression output shows that geo-thermal energy consumption had a significantly positive effect on economic growth *($\beta 4$ =218.3823 and $\rho<0.05$)*; thus, H_{03} was rejected. The findings of this study was in agreement with another study done by Onuonga, (2012), and Kundu, (2007).

The use of geothermal energy offers a more environmentally friendly and sustainable alternative to the combustion of fossil fuels. Geothermal energy can be used to generate both heat and power. In order to create geothermal power plants, large investments in infrastructure, drilling, and technology are required. These expenditures, in turn, encourage economic activity and the creation of new jobs. Increasing the use of geothermal power generation results in less reliance on external sources of energy, which in turn increases energy security while simultaneously lowering the cost of electricity for commercial and residential customers. In addition, geothermal projects frequently entail collaboration between government organizations, commercial firms, and local communities; this helps to establish partnerships and drives economic development on both the regional and national levels. In addition, the exploitation of geothermal energy makes a contribution to the preservation of the environment by lowering emissions of greenhouse gases and improving the quality of the air we breathe. The favorable correlation between the use of geothermal energy and economic expansion highlights the significance of investing in renewable energy sources for the sake of both long-term economic development and responsible stewardship of the natural environment.

5.0 RECOMMENDATION AND CONCLUSION

The Kenyan government should set ambitious targets for renewable energy consumption, such as a specific percentage of electricity generation or overall energy consumption. These targets can provide a clear direction and sense of urgency, encouraging investment and innovation in renewable energy technologies. The targets should be accompanied by a comprehensive roadmap outlining the necessary policy and regulatory frameworks to support their achievement. The Kenyan government should implement policies that offer financial incentives, such as tax credits, grants, and subsidies, can attract private investments in renewable energy projects. These incentives should target various scales of projects, including large-scale grid-connected systems and off-grid solutions for rural areas. Additionally, creating favorable financing options, such as low-interest loans and venture capital funds, can facilitate access to capital for renewable energy developers and entrepreneurs.

The Kenyan government should enhance and enforce regulatory frameworks specific to renewable energy can provide a stable and predictable investment environment. This includes streamlining permitting processes, establishing standardized power purchase agreements, and ensuring grid access and interconnection for renewable energy projects. A clear regulatory framework reduces barriers and uncertainties for investors, enabling them to navigate the renewable energy market with confidence. The Kenyan government should invest in research and development programs focused on renewable energy technologies, particularly those relevant to the Kenyan context. This includes fostering collaboration between research institutions, industry, and government agencies to develop innovative solutions, improve efficiency, and reduce the costs associated with renewable energy systems. Encouraging technology transfer and knowledge-sharing platforms can accelerate the adoption and adaptation of renewable energy technologies in Kenya. The Kenyan government should also invest in training programs and educational initiatives to build the capacity of the workforce in the renewable energy sector. This includes providing technical training, vocational programs, and university-level education focused on renewable energy engineering, project management, and policy development. Building a skilled workforce will support the growth of the renewable energy industry and enable Kenya to take advantage of the economic opportunities associated with clean energy.

Additionally, the Kenyan government should focus on expanding access to renewable energy solutions in rural areas, where energy access is limited. Implementing off-grid renewable energy systems, such as solar home systems and mini-grids, can provide clean and reliable electricity to rural communities. This not only improves the quality of life for individuals but also creates economic opportunities, stimulates local businesses, and enhances productivity in rural areas. In conclusion, the Kenyan government should foster collaboration between the public and private sectors to accelerate the deployment of renewable energy projects. Public-private partnerships can leverage the strengths and resources of sectors, enabling efficient project development, financing, and operation. By promoting these partnerships, the government can encourage private sector participation and ensure the effective utilization of public resources in the renewable energy sector.

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