# Effect of Renewable Energy Consumption on Economic Growth in Kenya

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## ABSTRACT

Despite Kenya having a massive generating capacity of renewable energy, its consumption levels remain significantly low. The low supply levels have driven the costs of production upwards leading to high energy prices thereby slowing economic activity occasioned by inadequate investments in the energy sector. However, there are conflicting results on the existing link between economic growth and renewable energy consumption in the developing world. This study purposed to establish the effect of renewable energy consumption on economic growth in Kenya. This study was anchored on the Neo-Classical Solow-Swan growth model. This study adopted the correlational research design and used time series data for the period 1980-2017 to determine the nature of the existing linkages. Capital and labour were incorporated as control variables. The granger causality results established the existence of a bidirectional and feedback relationship existing between renewable energy consumption and economic growth in Kenya. Vector Error Correction Model results showed that a unit increase in total renewable energy consumption led to a gross domestic product rise by 13,340 million dollars in the second year. Therefore, both the granger causality and Vector Error Correction Model (VECM) tests advocate for investment in the consumption of renewable energy if desired levels of economic growth are to be attained. Therefore, investment in modern energy generation and supply technologies and demonopolisation of the generation and supply of renewable energies to encourage private investments are recommended as the necessary measures to increase the level of renewable energy consumption, which in turn accelerates the rate of economic growth. Interventions such as tax exemptions on renewable energy equipment may encourage more uptake and consumption of renewable energies. This study may assist the government in the formulation of sustainable energy policies. This study may assist the government in the formulation of sound and sustainable energy policies for industrial and economic growth.

**Keywords;** Renewable energy, Economic growth, Kenya

## INTRODUCTION

Availability and accessibility to affordable and sustainable energy sources has for a long time been regarded as one of the most vital objectives of a sustained economic growth and development. This has been thought to be one of the preconditions for poverty alleviation and a catalyst for increased employment levels. Sustainable energy is energy that is capable of taking care of the current energy demands and needs sufficiently without compromising with the capability of future generations to meet their own energy needs.

Munene et al (2019) established that though Kenya's renewable energy consumption behavior is sustainable, it's not desirable if the much-envisaged level of industrialization is anything to go by. This expressly implies that if Kenya has to increase the share of manufacturing activities from the current 10 to 20 percent of Gross Domestic Product (GDP), more investments and better technology have to be employed in energy generation and supply.

Energy consumption refers to the usage of raw energy before its transformation. The total global energy consumption stood at $5.67\times10^{2}$ Megawatts (MW); which saw the figure grow by about 10percent in 2014, the greater percentage of this being from the nonrenewable energy sources. This serves to emphasize the crucial role played by energy in economic development. It is thought to be the key driver of economic development and industrialization. Furthermore, Singh, Nyuur and Richmond (2019) alludes that energy is pivotal in accelerating economic activities in economies; both developed and developing, since time immemorial. It castigates that nearly 80percent of the global energy consumption is majorly from the fossil fuels that leads to a mismatch in demand and supply given the high depletion rates of the nonrenewable ores in the long run. The overreliance on the depletible energy sources poses a risk to industrial processes that require huge amounts of energy to run, now and in the foreseeable future. Energy is the power that drives all major production activities; in fact, it is at the center of the attainment of Sustainable development goal number 7 of accessibility to affordable, sustainable and reliable energy, Vision 2030 and the highly anticipated Big 4 agenda.Energy poverty is a major hindrance to the attainment of the desired level of economic growth and its inadequacy is sure to lead to slowed economic progress hence, the global focus on renewable energy sources. Renewable energy is touted as the ‘fuel of the future’ by Singh et al (2019) and it acts as a key economic development driver by ensuring there is sufficient energies to power the envisaged industrialized economy now and in the foreseeable future due to the replenish ability of the renewable forms of energy.

Access to clean, sufficient, affordable and sustainable energy is also key in achieving the sustainable Development Goals’ dreams regarding good health and well-being, quality education and industrial development. Access to sustainable energy in modern times has come to be regarded as a key human survival issue. In fact, accessibility to insufficient and inadequate energy is regarded as a major drawback to economic progress in emerging economies (Butler, 2018). In light of these; it is therefore paramount to appreciate the crucial and very critical role played by energy in spurring economic growth in Kenya.

Previous studies have not taken keen interest in renewable energies and their impact on economic growth in Kenya; despite accounting for 72 percent of Kenya’s total energy consumption and topping Africa in renewable energy generating capacity. Despite the importance accorded to renewable energies in ensuring there is sustainable energy to cater for current and future household and industrial energy demands, limited studies exist to explain the relationship between the renewable energies and economic growth with the few available studies having the problem of aggregation by not isolating the specific effect of renewable energies on economic growth.

## LITERATURE REVIEW

Renewable energy consumption is the usage of energy, both by households and firms is treated as an important input in the production process (Singhet al.2019). Empirical studies herein are supported by the four different hypotheses from the energy consumption-economic growth nexus. These hypotheses are the growth hypothesis, neutrality hypothesis, feedback hypothesis and the conservation hypothesis**.** Growth hypothesis denotes a unidirectional causality relationship running from energy consumption to the level of economic growth. It emphasizes the critical role played by energy in accelerating and spurring economic progress. It therefore stipulates that any inaccessibility to modern energy acts as a suppressor to economic growth. Conservation hypothesis advocates for conservation and energy efficient policies that have no negative impact on the economy. It implies that economic growth is the dynamic that brings about an energy sector that is less energy dependent. The hypothesis conforms to the bidirectional independence existing between economic growth and energy consumption. This is meant to advocate and champion for the implementation of energy expansionary measures for the realization of sustainable progress in the economy**.**

Feedback hypothesis connotes a complimentary relationship existing between energy consumption and economic growth which is supported if there is a bidirectional energy-economic growth kind of relationship. Neutrality hypothesis, on the other hand, propounds that there exists no significant association between energy and economic growth, and if any, it's by mere coincidence and not design. Jakovac (2018) did a study on electricity-economic growth nexus in Croatia and identified a positive correlation between the two variables. However, it suggests use of new and robust econometric tools and use of new sets of data to counter the inconsistencies and conflicting results past studies have subjected us to. It suggests that new variables such as capital and labour should be incorporated. This study mitigated the inadequacies and adopted the recommendations by of Jakovac (2018) by incorporating capital and labour as the control variables. Investments were also incorporated to make the study more robust. This is because energy consumption is not the only determinant of economic growth, but a host of other factors, too.

Neutrality hypothesis is supported by the likes of Seetharaman et al. (2019). In its analysis of the nexus between renewable energy consumption and economic growth, established that it is in fact the technological, social and the regulatory bottlenecks that suppress the development of renewable energy development and the two variables have nothing to do with each other.

Another class of researchers asserted that there exists a long-term relationship running from economic growth to energy consumption, and not the other way round. Their findings are supported by the conservation hypothesis. This hypothesis is supported by Li and Leung (2021). Thus, a reduction in the level of energy consumption would not adversely affect economic growth. They advocate for the implementation of energy conservation policies to accelerate economic growth. Conservation hypothesis postulates that economic growth plays a very important function in energy consumption as lauded by Souhila and Kourbali (2012) that established a unidirectional granger-causality relationship running from economic growth to energy consumption though magnitudes of the relations were overlooked. Ameyaw et al. (2017) also asserts the conservation hypothesis; the granger causality tests conducted on the data from 1970-2014 indicated that there exists a unidirectional causality running from GDP growth to electricity consumption. The studies above, apart from Ameyawet al. (2017), are from the developed economies and may therefore not portray the energy situation in Kenya.

Jakovac (2017) in its analysis on the overview of electricity consumption and economic growth in Croatia used granger causality analysis and established existence of positive causality existing between energy consumption and economic growth. Other studies in consonance with the findings of Jakovac (2018) are; Ito (2017), and Bhattacharyaet al. (2016). The studies, however, are silent on the intensity of the causal relationship. This set of results is also consistent with the findings of Buiyan et al. (2022). The studies also made use of the granger causality test which is incapable of detecting more than one cointegrating relationship. These findings are also consistent with the findings of Gabr and Mohamed (2020) and Islam et al. (2021). The studies are also from developed economies and may therefore not portray the real situation in developing economies like Kenya. VECM that has been exploited in this study is capable of determining the magnitude and direction of any causal relationship amongst the study variables.

Singhet al**.** (2019), employing the Fully Modified Ordinary Least Squares (FMOLS) technique and data for the period 1995-2016 in 20 developing countries, established that a 1 percent increase in renewable energy consumption led to a 0.07 percent increase in economic output in developed economies while it only led to a 0.05percent rise in developing economies. This study, however, assumed all the developing economies had similar energy situations. It is possible for economies to be at the same stage of economic development but have varying energy situations due to the difference in their geographic locations, political climate and country-specific energy policies. That is why this study concentrated on the Kenyan case.

Blochet al. (2015) in China made use of annual data for 1969,1973,1997,1998,2001,2002 and 2003 using the Autoregressive Distributed Lag (ARDL) and VECM and established a bidirectional association between renewable energy consumption and the level of economic growth. The study, apart from being a developed nation study, made of data that is not continuous, it instead made use of disjointed data and therefore the outcome of the study cannot really be relied upon to inform sound energy policies because the data was biased. There was no economic justification for using the disjointed data hence, unreliable. The study also settled on fewer observations that are deemed inadequate for a sound econometric study. This study corrected this by using continuous data for the period 1980-2017(38 observations).

From a regional perspective, Ajayiet al. (2022) in Nigeria in its assessment of the effects of sustainable energy on climatic conditions, job creation and food security, established that renewable energy consumption led to economic growth and recommended the increased renewable energyuptake. The study, however, focused on an energy sufficient country, Nigeria, and hence the findings do not mirror the situation in most of the energy deficient African economies.

Some studies found mixed results and could not really provide a clear conclusion on the effect of renewable energy consumption on economic growth. Ziramba (2013) asserts this hypothesis. There’s also a class of energy economists like Okyay, Yucel and Ebru (2015), in their article on ‘Energy consumption and economic growth nexus, a study of the developed European nations’ used the granger causality and interestingly found that renewable energy positively affected economic growth while non-renewable energy consumption negatively impacts economic growth. It is of interest to energy economists in developing economies such as Kenya to also establish if the above inconsistencies arise and adequately address them.

Amri (2017) sought to establish the nature of the relationship between energy consumption and economic growth and also found mixed results. The findings from his ARDL model established a long run causality existing between non-renewable energy consumption but no cointegration existed between renewable energy consumed and the level of economic growth. He, however, established a long run bidirectional relationship between nonrenewable energy consumption and economic growth. Furthermore; he established a unidirectional causality running from renewable energy consumption and economic growth in the long run. This study, therefore, sought to address the inconsistencies in the previous findings.

Majority of these discrepancies were widely attributed to the use of Engle-Granger cointegration procedures which have been downplayed due to its low power and size properties of associated samples though this has been addressed by the more recent studies exploiting more robust, Johansen’s, VECM, Toda-Yamamoto and Dolado-Lutkepohl which are conducted whether the variables have a unit root or not. They are also conducted whether there is cointegration amongst variables or not.

The previous studies have several gaps that need to be filled; theoretical, methodological and empirical gaps. Methodological gaps in this study encompass all gaps regarding exploitation of traditional analysis techniques by past scholars. Empirical gaps include studies that were done in the developed economies and may therefore not be replicable to the Kenyan case and the fact that various studies posed mixed and conflicting results on the nexus between renewable energy and economic growth. A theoretical gap in the energy-economic growth nexus concerns the use of the Cobb-Douglas model with capital (K) and labour (L) only to explain growth in GDP, thereby ignoring important factors like energy investment and consumption. The Cobb-Douglas model therefore had to be operationalized to include renewable energy investments and consumption.

## RESEARCH METHODOLOGY

This study adopted the correlational research design to unravel the nature of the relationship existing between renewable energies and economic growth. The correlational research design was chosen as it’s a research design capable of establishing the nature of relationships between variables. Annual time series data from the Energy Information Administration and World Bank databases for the period 1980-2017 was used to establish the relationship existing between the key renewable energy forms and economic growth. The study therefore adopted secondary time series energy consumption data acquired from the official World Bank Database.

This study targeted the volumes of renewable energy in million kilowatts that were consumed and the corresponding renewable energy investments over the period under study (1980-2017). The study therefore considered a time period of 38 years. This study period was selected as it's the period that preceded the global oil crisis that brought the topic of sustainability and efficiency in energy value chain in focus. It is also the period that preceded massive investments and exploitation of renewable energy sources as alternative energy sources to mitigate the global oil crisis.

This study adopted the Cobb Douglas production function to explain the relationship between the key renewable energy forms and economic growth (the key renewable energy forms are hydro-power, wind, solar and geothermal energies). The Cobb-Douglas production theory showed that energy investment and consumption determine the level of output and GDP. This, however, can be affected by extraneous variables, capital and labour. Cobb-Douglas production function is however crucial in estimating the relationship where the function is nonlinear in variables with non-constant slope

The following model was adopted;

$$Y_t = A + B_1K + B_2L + B_3TREC_t + \varepsilon_{(t)}$$

Where $A$ is a constant

$Y_t$ is the GPD

$K$ is capital

$L$ is labour

$TREC_t$ is total renewable energy consumed at time $t$

$\varepsilon_{(t)}$ is the error term

## RESULTS AND DISCUSSION

### Descriptive statistics

Descriptive statistics were run to define the basic distributional characteristics of GDP, renewable energy and the control variables' data. Computation of the mean, maximum, minimum, standard deviation, Skewness and kurtosis was designed to reveal how good the data under consideration was. The mean was meant to give the overall average of the frequencies. The standard deviation defined the dispersion within the distribution while trend analysis helped assess the movement of renewable energy consumption vis a vis investment to determine long run sustainability. The Skewness, kurtosis and Jarque-Bera were meant to also test for the normality of the data.

Table 1: Descriptive statistics

| | GDP | TREC | K | L |
|---|---|---|---|---|
| Mean | 90.00000 | 3.230229 | 17.79102 | 13.95605 |
| Maximum | 190.0000 | 5.180000 | 40.81200 | 22.40000 |

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| | | | | |
|---|---|---|---|---|
| Minimum | 31.00000 | 1.182000 | 6.748700 | 8.870000 |
| Skewness | 0.718672 | -0.230624 | 0.934972 | 0.660348 |
| Kurtosis | 1.959598 | 2.311474 | 2.269833 | 2.312029 |
| Jarque-Bera | 4.984963 | 1.087461 | 6.380571 | 3.511107 |
| Sum | 3420.000 | 122.7487 | 676.0589 | 530.3300 |
| Observations | 38 | 38 | 38 | 38 |

From Table 1 above, the findings indicate that the variables are symmetric. It therefore rejected the null hypothesis that the variables were not normally distributed around their mean. The distributions are platykurtic to the means as all the three sets of data have a kurtosis value of less than 3. (A normal distribution should have a kurtosis value of 3). The kurtosis values also show that there are no extreme variations in the distributions relative to the normal.

The Skewness of a normal distribution is zero. Therefore, the positive skewness values (0.718672, 0.934972 and 0.660348) for GDP, capital and labour imply the distribution had a slightly longer right tail. The data was therefore symmetrical, whereas the total renewable energy consumed had a slightly longer left tail as depicted by the slightly negative values of skewness. The mean of GPD over the 38 years was established to be 90.00000 (million dollars), this being the average of the 38 observations. The mean capital and labour employed over the 38 years was found to be 17.79102 million dollars and 13.95605 million people respectively, these being the averages for the study period.

The maximum and minimum values for GDP were found to be 190.0000 million dollars (value for the year 2012) and 31.00000 million dollars for the year 1986 respectfully. The highest consumption of the renewable energy was observed to be 5.180000 million kilowatts (2010) while the lowest consumption was 1.182000 million kilowatts, an amount consumed in the year 1980. The highest number of the productive population was found to be 22.40000 million people, being the workforce for 2017 while the minimum labour force was observed in 1988(8.870000 million people). All the variables have a kurtosis value of less than 3 implying the data is platykurtic. Since kurtosis measures how tall or flat (pickedness) of a distribution, it was observed that the normal distribution was relatively flat.

**Stationarity Test Results**

In order to test for stationarity properties of the study variables the study employed the Augmented Dickey Fuller test (ADF). The results in table 2 indicate that all the variables of interest were integrated of order one.

Table 2: ADF test results

| | **At Level** | | | **At First Difference** | | | **Inference** |
|---|---|---|---|---|---|---|---|
| **Variables** | **t-statistic** | **Critical values 1% 5%** | **P-value** | **t-statistic** | **Critical values 1% 5%** | **P-value** | |
| GDP | 0.756928 | -3.621023 | 0.9918 | -4.489095 | -3.632900 | 0.0010 | I (I) |
| | | -2.943427 | | | -2.948404 | | |
| TREC | -2.827786 | -3.621023 | 0.0641 | -6.464215 | -3.632900 | 0.0000 | I (1) |
| | | -2.943427 | | | -2.948404 | | |
| K | 0.022871 | -3.621023 | 0.9548 | -5.170973 | -3.626784 | 0.0001 | I (1) |
| | | -2.943427 | | | -2.945842 | | |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| L | 3.59961 | -3.679322<br>-2.967767 | 1.0000 | -3.774912 | -3.679322<br>-2.967767 | 0.0079 | I (1) |

(Source, own computation, 2020)

**Cointegration Relationship**

Test for cointegration was carried out to establish the presence of long run relationship amongst the variables. The Johansen test, Trace and Maximum Eigen value tests were carried out. This test involved testing the null hypothesis of zero cointegrating relationships against the alternative hypothesis of one or more cointegrating relationships. Therefore, the test sought to establish the existence of a long run relationship existing amongst the study variables. Variables are cointegrated if they have a long run equilibrium relationship between them, that is, they move in the same direction. It's a technique meant to analyze data that is not stationary at levels. This technique was exploited due to the existence of a unit root in the variables. Johansen Cointegration test was done with lags and results obtained. Cointegration test was done to test the null hypothesis of zero cointegrating relationships against the alternative hypothesis of 1 or more cointegrating relationships. The null hypothesis was rejected as there were cointegrating relationships.

Table 3-Cointegration Test Results

| Unrestricted Cointegration Rank Test (Trace) | | | | |
|---|---|---|---|---|
| Hypothesized | | Trace | 0.05 | |
| No. of CE(s) | Eigen value | Statistic | Critical Value | Prob.** |
| None * | 0.830725 | 74.23016 | 29.79707 | 0.0000 |
| At most 1 * | 0.409983 | 17.39085 | 15.49471 | 0.0256 |
| At most 2 | 0.015735 | 0.507525 | 3.841466 | 0.4762 |
| Trace test indicates 2 cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |
| Unrestricted Cointegration Rank Test (Maximum Eigen value) | | | | |
| Hypothesized | | Max-Eigen | 0.05 | |
| No. of CE(s) | Eigen value | Statistic | Critical Value | Prob.** |
| None * | 0.830725 | 56.83930 | 21.13162 | 0.0000 |
| At most 1 * | 0.409983 | 16.88333 | 14.26460 | 0.0188 |
| At most 2 | 0.015735 | 0.507525 | 3.841466 | 0.4762 |
| Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |
| Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I): | | | | |
| GDP | TREC | | | |
| -0.142399 | -1.668562 | | | |
| -0.024533 | 8.891751 | | | |
| -0.174458 | -0.835160 | | | |
| Unrestricted Adjustment Coefficients (alpha): | | | | |
| D(GDP) | 5.328225 | 0.715491 | -0.168225 | |
| D(TREC) | 0.143921 | -0.212948 | -0.020216 | |
| Sample (adjusted): 1986 2017 | | | | |

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| | | |
|---|---|---|
| Included observations: 32 after adjustments | | |
| Trend assumption: Linear deterministic trend | | |
| Series: GDP TREC | | |
| Exogenous series: K L | | |
| Warning: Critical values assume no exogenous series | | |
| Lags interval (in first differences): 1 to 5 | | |

(Source, own computation)

In estimating the Johansen Cointegration, two variables Capital and Labour were added as exogenous variables to be considered. From the table, the null hypothesis of no cointegration was rejected at none and at most 1 cointegrating equation. Using Trace test and the Maximum Eigen value test, the Johansen Cointegration test showed that there were two cointegrating equations at the 0.05 level.

In the long run, with GDP designated as the dependent variable, the Johansen Normalization cointegrating equation results appears as shown in tables 4;

Table 4: Cointegration Test Results

| | | | | |
|---|---|---|---|---|
| 1 Cointegrating Equation(s): | | Log likelihood | -36.89606 | |
| Normalized cointegrating coefficients (standard error in parentheses) | | | | |
| GDP | TREC | | | |
| 1.000000 | 11.71754 | | | |
| | (7.96219) | | | |
| Adjustment coefficients (standard error in parentheses) | | | | |
| D(GDP) | -0.758732 | | | |
| | (0.11737) | | | |
| D(TREC) | -0.020494 | | | |
| | (0.01482) | | | |
| 2 Cointegrating Equation(s): | | Log likelihood | -28.45440 | |
| Normalized cointegrating coefficients (standard error in parentheses) | | | | |
| GDP | TREC | | | |
| 1.000000 | 0.000000 | | | |
| 0.000000 | 1.000000 | | | |
| Adjustment coefficients (standard error in parentheses) | | | | |
| D(GDP) | -0.776286 | -2.528506 | | |
| | (0.11560) | (7.23766) | | |
| D(TREC) | -0.015270 | -2.133621 | | |
| | (0.01238) | (0.77523) | | |

Two cointegration results were obtained; the Trace and the Eigen value. The null hypothesis of no cointegration equation and at most one cointegration equation were rejected, both by the Trace and maximum Eigen values. Overally, the test indicated that there existed one cointegrating equation. Considering the normalized cointegrating coefficients, GDP was incorporated as the dependent variable. In the long run, signs of the coefficients are reversed and thus the results show that GDP is positively related to TREC paribus. The null hypothesis of no cointegration was rejected against the alternative hypothesis of a

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cointegrating relationship in the model

In order to determine cointegration between the variables, Trace and Eigen value techniques were used based on the null hypothesis of no cointegration. Findings indicated that both the unrestricted cointegration Rank and unrestricted cointegration Rank test (maximum Eigen value) indicated the presence of cointegrating equation at 0.05 level of significance with (p=0.001), by rejecting the null hypothesis of no cointegrating equations. Further findings indicated a positive association in the long run between GDP and total renewable energy investments, consumption, capital and labour.

**Lag length Determination**

Since one independent variable in a series could affect the dependent variable belatedly, it was critical that a lag length be determined. A Vector Auto-regressive Model was estimated and used to establish the lag length. The Vector Auto-regressive Model assumes that the error term's conditional mean is zero. The optimal lag length estimation yielded the results as shown in table 5;

Table 5: VAR Test Results

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -300.3522 | NA | 74.95623 | 18.50620 | 18.73294 | 18.58249 |
| 1 | -197.4112 | 168.4490 | 0.679466 | 13.78250 | 15.14296 | 14.24025 |
| 2 | -181.8560 | 20.74025 | 1.347062 | 14.35491 | 16.84909 | 15.19412 |
| 3 | -139.0488 | 44.10440* | 0.625533 | 13.27568 | 16.90358 | 14.49636 |
| 4 | -96.12020 | 31.22079 | 0.430189 | 12.18910 | 16.95072 | 13.79124 |
| 5 | -14.11251 | 34.79114 | 0.068842* | 8.734091* | 14.62942* | 10.71769* |
| * Indicates lag order selected by the criterion | | | | | | |

Using the Akaike Information Criterion (AIC), the appropriate optimal lag selected is 5 which is premised on the fact that the lower the value of AIC, the better the model and the fact that it has a less harsh penalty for adding regressors to the model. This is also the lag length selected by most criterions such as Final Prediction Error (FPE) Schwarz criterion (SC) and the Hannan-Quinn (HQ) criterion.

**Vector Error Correction Model (VECM)**

Since there was cointegration established, it was thus important to estimate the Vector Error Correction Model using lags because of using annual data.

Table 6: VECM Results

| Cointegrating Eq: | CointEq1 | |
|---|---|---|
| GDP(-1) | 1.000000 | |
| TREC(-1) | -2.027698 | |
| | (7.25740) | |
| | [-0.27940] | |
| C | -16.25241 | |
| Error Correction: | D(GDP) | D(TREC) |
| CointEq1 | -0.637764 | -0.011972 |
| | (0.09835) | (0.01204) |

| | | |
|---|---|---|
| | [-6.48489] | [-0.99454] |
| D(GDP(-1)) | -0.268861 | -0.025812 |
| | (0.12383) | (0.01516) |
| | [-2.17118] | [-1.70300] |
| D(GDP(-2)) | -0.288348 | 0.013340 |
| | (0.12731) | (0.01558) |
| | [-2.26499] | [ 0.85613] |
| D(GDP(-3)) | -0.288757 | -0.007316 |
| | (0.14450) | (0.01769) |
| | [-1.99829] | [-0.41366] |
| D(GDP(-4)) | -0.269569 | -0.044773 |
| | (0.15258) | (0.01868) |
| | [-1.76674] | [-2.39739] |
| D(TREC(-1)) | 4.124137 | -0.334759 |
| | (1.94614) | (0.23821) |
| | [ 2.11914] | [-1.40533] |
| D(TREC(-2)) | 4.581434 | -0.032954 |
| | (2.07177) | (0.25358) |
| | [ 2.21136] | [-0.12995] |
| D(TREC(-3)) | 4.125101 | -0.162495 |
| | (2.27405) | (0.27834) |
| | [ 1.81399] | [-0.58379] |
| D(TREC(-4)) | 2.234807 | -0.015853 |
| | (2.21601) | (0.27124) |
| | [ 1.00848] | [-0.05845] |
| C | -49.78508 | -0.982979 |
| | (11.5463) | (1.41326) |
| | [-4.31179] | [-0.69554] |
| K | 2.372004 | 0.036540 |
| | (0.30008) | (0.03673) |
| | [ 7.90448] | [ 0.99481] |
| L | 0.997588 | 0.043482 |
| | (0.78727) | (0.09636) |
| | [ 1.26715] | [ 0.45124] |
| R-squared | 0.869293 | 0.681698 |
| Adj. R-squared | 0.753963 | 0.400844 |
| Sum sq. resids | 353.6461 | 5.298231 |
| S.E. equation | 4.560999 | 0.558266 |
| F-statistic | 7.537447 | 2.427230 |
| Log likelihood | -85.95949 | -16.64425 |
| Akaike AIC | 6.179363 | 1.978439 |
| Schwarz SC | 6.904943 | 2.704019 |

| | | |
|---|---|---|
| Mean dependent | 4.363636 | 0.036021 |
| S.D. dependent | 9.195169 | 0.721225 |

The above VECM results show the existence of both short run relationships with an expected negative coefficient of the error correction mechanism of -0.637764.

**Granger causality Test**

The existence of cointegration implies that there's either unidirectional or bidirectional causality amongst the study variables. In order to establish the causality link between renewable energy consumption and economic growth, the granger causality test was used.

Table 7: Granger causality Results

| Null Hypothesis: | Obs | F-Statistic | Prob. |
|---|---|---|---|
| TREC does not Granger Cause GDP | 33 | 1.45196 | 0.2455 |
| GDP does not Granger Cause TREC | | 1.52942 | 0.2215 |
| K does not Granger Cause GDP | 33 | 0.88429 | 0.5081 |
| GDP does not Granger Cause K | | 1.32939 | 0.2886 |
| L does not Granger Cause GDP | 33 | 0.56455 | 0.7261 |
| GDP does not Granger Cause L | | 3.29780 | 0.0226 |
| K does not Granger Cause TREC | 33 | 1.34737 | 0.2818 |
| TREC does not Granger Cause K | | 2.55342 | 0.0574 |
| L does not Granger Cause TREC | 33 | 0.16828 | 0.9716 |
| TREC does not Granger Cause L | | 2.22540 | 0.0880 |
| L does not Granger Cause K | 33 | 0.78241 | 0.5732 |
| K does not Granger Cause L | | 1.07977 | 0.3987 |
| Pairwise granger causality test; Sample: 1980 2017; lags 5 | | | |

From the table above, the null hypothesis that the total renewable energy consumption does not granger-cause economic growth was rejected as the probability is greater than 0.05 (0.2455). Therefore, total renewable energy consumption brings about an increase in the level of GDP. On the other hand, a GDP growth leads to an increase in the level of the total renewable energy consumed as the null hypothesis that GDP growth does not granger causes total renewable energy consumed was rejected (p=0.2215).

Therefore, the granger causality results in table 7 establish a feedback relationship between renewable energy consumption and the level of economic growth. The test conforms to the feedback hypothesis of the Energy-Economic growth nexus proposition.

## CONCLUSION AND POLICY IMPLICATION

Renewable energy consumption was observed to have substantial effect on economic growth in Kenya in the long run. Since renewable energy consumption is seen to steer economic growth through industrialization, this study recommends that Kenya as a least developed country implements interventions aimed at increasing renewable energy consumption in all sectors of its economy as this will give impetus the process of accelerating sustainable economic growth as envisaged in vision 2030 and the Sustainable Development Goals (SDGs).This can be done by adopting measures aimed at reducing the high energy prices in the economy by investing in modern energy generation and supply equipment. This study may

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therefore help scholars to appreciate the contribution of renewable energy consumption towards steering sustainable economic growth by eradicating energy poverty. Further it forms a foundation for further studies by creating a new angle of thinking and doing things, out and about the field of sustainable energy for economic development

**Limitations of the Study**

This study used time series data to establish the nature of the relationship existing between renewable energy consumption and economic growth in Kenya. A panel study including more African economies could have been exploited to establish the nature of relationship existing between the variables across the borders of the East African economies. However, it's noted that majority of East African economies are at the same stage of economic development and therefore the findings of this study can be replicated in most of the African economies.

**Areas for Further Research**

This study recommends that further research be done using panel data of the East Africa community countries. This will inform policy for the entire region as there are limited trade restrictions within the member states. Cross sectional renewable energy data on the East African countries will also help in specialization in specific kinds of renewable energy as countries will now engage in renewable energy investment, supply and consumption of the kinds that they have comparative advantage in generating and consuming. Joint energy policies for the region should be encouraged as it also helps foster cross border cooperation amongst member states.

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