Sisodia, Gyanendra Singh; Sah, Hemant Kumar; Kratou, Hajer et al.

Article

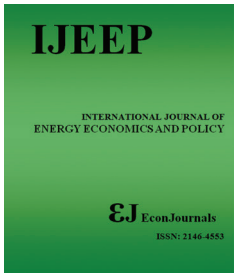
The long-run effect of carbon emission and economic growth in European countries : a computational analysis through vector error correction model

International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Sisodia, Gyanendra Singh/Sah, Hemant Kumar et. al. (2023). The long-run effect of carbon emission and economic growth in European countries : a computational analysis through vector error correction model. In: International Journal of Energy Economics and Policy 13 (3), S. 271 - 278. https://www.econjournals.com/index.php/ijeep/article/download/13942/7306/33276. doi:10.32479/ijeep.13942.

This Version is available at:
http://hdl.handle.net/11159/630210



International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(3), 271-278.

The Long-Run Effect of Carbon Emission and Economic Growth in European Countries: A Computational Analysis through Vector Error Correction Model

Gyanendra Singh Sisodia[1], Hemant Kumar Sah[2], Hajer Kratou[1]*, Rajesh Mohnot[1], Alberto Ibanez[3,4], Bhumika Gupta[5,6]

[1]College of Business Administration, Ajman University, United Arab Emirates, [2]Alliance University, Bangalore, India, [3]College of Business Administration, University of Science and Technology of Fujairah, United Arab Emirates, [4]Universidad Ecotec, K.M 13.5 Samborondon, Ecuador, [5]Institut Mines- Telecom Business School, LITEM, Univ Evry, IMT-BS, Université Paris-Saclay, Department Management, Marketing and Strategy, 9, Rue Charles Fourier, 91011, Evry, France, [6]Alliance University, Bangalore, India. *Email: h.kratou@ajman.ac.ae

Received: 20 December 2022 **Accepted:** 28 March 2023 **DOI:** https://doi.org/10.32479/ijeep.13942

ABSTRACT

The paper seeks to examine the association that exists among a number of energy-related variables such as energy use, renewable energy use, carbon pollutants and the economic growth of European Union countries. The examination of variables focus on twenty-one years of data from 2000 to 2020 using a multidimensional data framework. The findings come from empirical analysis carried out using panel VECM model and associated tests such as, panel unit root test, cointegration and the causality one. The different variables indicated above have positive effects on the growth of economies in various EU member states. Results obtained from the use of the heterogeneous causality test indicated that there is an indirect causality between energy use and the rate at which economies develop. Based on the findings obtained from the study, there is a need for EU member states to establish policies that should help to enhance efficiency in energy use to promote economic development.

Keywords: Energy, Economic Development, Renewable Energy, GDP and Carbon Release
JEL Classifications: O1; O4; Q43 and Q56

1. INTRODUCTION

The problem of environmental pollution is increasing around the world since few decades. Such increment is experienced by both developed and developing countries. Countries like China, the United States of America, European Union (EU27) and UK, Russia, Japan India and G20 member countries and India have become significant Green- house gas emitter in the world (Emissions Gap Report 2020)[1]. One prime reason of such emission is non- renewable energy consumption (coal and fossil fuels). Changes brought about by global warming and climate crisis have caused an increase in the rate of carbon emissions to the atmosphere which influenced by the fossil fuel consumption that significantly contributed more than 90% of carbon dioxide emission in the world (Radmehr et al., 2021; Bölük and Mert, 2014).

The focus of renewable energy generation goes back to the Kyoto convention and oil crisis in the early 1990s. With an aim to reduce the rate of carbon emissions to the atmosphere, the Kyoto protocol and Paris agreements were established. From one side, the Kyoto Protocol aims to bring the Green House Gas (GHG) levels in

1 Emission Gap Report 2020. Downloaded on 2021. https://wedocs.unep.org/bitstream/handle/20.500.11822/34438/EGR20ESE.pdf

the atmosphere to 2 degrees Celsius. From the other, the Paris Agreement indicated that since EU member states contribute to the highest emission of poisonous gases to the atmosphere, they have to show a commitment in bringing about changes (Radmehr et al, 2021; González et al., 2014). Further, United Nations Framework Convention on Climate Change (UNFCCC) has shifted its focus for National policies towards renewable sources of energy generation for the world. In the same vein, Purnomo et al. (2023) recommend that increasing the number of energy sources and developing more infrastructure support and boost the supply of energy and thus improve energy reserves. Moreover, in 2015, the adoption of Sustainable Development Goals in its Agenda 2030 supports for sustainable future with a key target is to limiting the global temperature below 2 degrees Celsius (Gielen et al., 2019). An estimation shows that the growth of renewable energy from 15% to 63% in between 2015 and 2050 can help to provide emission reduction in significant amount (94%). The clean and affordable energy is adopted in SDGs motivates to nation to promote production and consumption of renewable energy sources. Sustainable energy is considered among the most critical global development agenda points. It plays a pivotal role not only in running the industry but also the household (Rasool et al., 2022).

It is generally known that renewable energy causes a rebalance in economic growth through better quality of environment. This has incentivized numerous nations, especially the EU member states to pay greater attention to renewable energy usage. The aims to reduce the green-house gas emission and climate change mitigation has influenced the EU countries to become the world leader in the renewable energy uses (Okyay et al., 2014). The motivation behind this is to get energy saving, reduction of green- house gas emission and increment of renewable energy in the energy mix. A report of European Environment Agency shows that the share of renewable energy uses in the EU has increased more than double from 2004 to 2018 (Smolović et al., 2020). Further, this period has extended till 2030 and directed to all EU member states to increase the share of renewable energy integration in the energy supply to enhance energy supply mix, energy security and environmental protection to promote social development. The EUs climate and energy framework highlights a target of 32% in contribution of renewable energy usage and efficiency of a similar rate. Energy use helps to promote the rate of production, thus enhancing people's living' standards. The study seeks to apply a new econometric approach to evaluate how economic development and the use of energy from renewable sources relate (Saidi and Omri, 2020).

This study focuses on the relationship that exists between the energy utilization from both renewable and non-renewable sources over the long run among EU member states. Data are collected for the period between 2000 and 2020 and analyzed using E-views modelling. The different factors that were considering during the evaluation included energy use, GDP as a proxy of economic development and creation of renewable energy. EU member states were selected for the study since they cover about eighty percent of total inland energy use of the studied period. Further, the background and characteristics of the selected economies are similar. This paper is guided by two research questions: (1) What is the relationship between energy use and economic development?: and (2) Can establishing limits to energy use affect economic growth?

The novelty of this study is to identify how EU member states can leverage on energy use to enhance fiscal growth. Energy use is said to stimulate economic growth by promoting production activities (Mahmood and Ahmad, 2018). Conversely, increased production activities are said to have a great contribution towards carbon emissions, hence this requires a great need to control them. This study suggests that renewable sources of energy usage support production activities. This should help to ensure that energy use contributes to economic growth while also preserving the environment.

The organization of paper is as follows. In section 2, the study starts with a literature review which provides theoretical background about the research topic. This helps to give an insight about the relationship that exists between the different variables. In section 3, we discuss the selected variables and data based on desired outcomes, as well as we present the methodology. The paper also presents a preview of the panel unit root and cointegration tests. It also discusses the panel-based VECM model. Section 4 presents the results and provides a discussion. Section 5 concludes and discusses the limitation and provide further recommendations for future study.

2. LITERATURE REVIEW

This section presents the review of literature from various studies on Economic Growth, Energy Consumption and Carbon Emission. This should inform about the framework of the relationship that exists between energy use and economic development among EU member states.

The connection between fiscal growth and energy usage can be defined using four hypotheses.

The first hypothesis indicates that energy use has both direct and indirect influence on how an economy grows and other factors that are likely to have an effect. Due to the fact that energy consumption results in the development of an economy, any decisions made regarding the issue influence productivity. However, the second hypothesis reverses the approach proposed by the first one since it indicates that energy use is directly influenced by production. Increased production activities enable people to live in high standards which in the long run promotes energy use.

The second hypothesis is defined as hypothesis of conservation. This indicates that policies established with the aim of limiting energy use is not likely to have an adverse impact on production. Another hypothesis is based on the feedback loop which suggests that energy use has an effect in economic development whereas a growth of the economy affects production rate negatively. In this case, an economy whose development is affected negatively is likely to see a reduction in the demand for energy. The last hypothesis is the neutrality one which suggests that no influence exists between the use of energy and economic development. According to Apergis and Payne, (2012) reducing energy use or decisions aimed at limiting energy use does not have any effect

on the rate the economy progresses. A more recent study by Surya et al. (2021) contradicts the neutrality hypothesis. The latter show that the direction of the sustainable development of the area is a very important factor to optimize the use of renewable energy towards environmental, economic, and social sustainability. An old study by Kraft and Kraft (1978), they carried out a research study to evaluate the affiliation that exists between energy usage and the rate at which an economy develops. The research focused on the U.S economy between 1947 and 1974 and provided a breakthrough on the subject since its findings indicated there is a one-way bond between the two variables. In the same vein, Apergis and Tang (2013) evaluate the connection between the pair of variables in eighty-five nations undergoing different levels of growth. The research uses the Granger causality and covers the time frame of 1975 to 2007. The procedure underwent modification in the hands of Toda and Yamamoto together with Dolado and Lutkepol. The study's findings confirm the hypothesis of growth in forty-six countries. Increasing the number of control variables in the research study caused an upsurge in economies whereby greater energy use correlated with productivity rates. However, the relationship depends significantly on the development level of countries under study. Rich countries indicated strong support for the growth hypothesis when compared to poor ones. The authors suggest that poor countries have a high dependence on labor thus reducing consumption of energy.

In another stream of studies, Ouedraogo (2013) investigates fifteen countries affiliated to the Economic Community of West African States (ECOWAS) for the period between 1980 to 2008. The author applied cointegration panel models to verify whether a relationship exists between energy use and the rate at which economies grow. One of the findings recorded from the study is that energy use within a short period is heavily influenced by any changes that take place in production processes, whereas energy use in the long-term influences production significantly. Further, it indicates that limiting energy use can affect the rate at which an economy grows within an extended period.

In a study on Indonesia, Malaysia, Philippines and Thailand, Chontanawat (2020) evaluates the relationship that exists between energy use, CO_2 emissions and the rate economies advance, using time series to assess the relationship between energy usage and fiscal growth and the "Johansen co-integration" and "Granger causality. The study findings indicated there subsists a long-term affiliation between the two variables even though it was one way for all cases. The results however varied across the studied countries. Thailand, alongside Malaysia and Indonesia indicated there's a causal link between the variables which was not the case in the Philippines. This indicates that any policies aimed at limiting energy use are not likely to affect production in the three countries but would have a negative effect in the Philippines. The finding of study suggests the use of alternative sources of energy to eliminate the challenge. In the same vein, Destek and Aslan (2017) focused on evaluating the connection between fiscal growth and the usage of both renewable and non-renewable energy. The study assessed 17 growing economies between 1980 and 2012. Bootstrap panels were used to carry out causality research. When focusing on renewable energy usage, the hypothesis suggesting growth was observed in Peru only with the conservation one being observed in Thailand and Colombia. South Korea and Greece supported the feedback hypothesis, but no influence was observed in 12 economies. In the case of non-renewable energy usage and the rate the economies the results were different. The growth hypothesis was confirmed not only in China and Colombia, but also in the Philippines and Mexico, whereas the conversation one was observed in Egypt, Portugal, and Peru. A two way bond between the variables was only be observed in Turkey. Moreover, the use of non-renewable energy and economic development did not have a relationship in the remaining countries. The positive impact of the use of energy from renewable sources on production activities has been also confirmed by Radmehr et al. (2021). The study was carried out in the period between 1995 and 2014 in twenty-one EU member states. An upsurge in production activities contributes to enhanced renewable energy usage, indicating that the two variables go hand in hand. While in a study by Coers and Sanders (2013) evaluated the association between GDP and energy use from 1960 to 2000 using the error correction method. Results indicated that a relationship only exists between production and consumption. In this case energy should not be relied upon as a significant factor in promoting production.

In a study on short and long run causal nexus between renewable energy, CO_2 and economic growth, covering Commonwealth of Independent States (CIS), Avazkhodjaev et al. (2022) show that estimation suggested that renewable energy generation has a significant short and long-run positive effect on CO_2 emissions and economic growth in the selected countries. They recommend that energy policy must be designed with the development of the economy, the development of the environment, and the use of renewable energy sources in the countries in mind. In a more diversified country' sample including twenty-two developed and eighteen developing from 1965 to 2002 and using a panel VAR, based on the generalization of moments, Lee and Chang (2007) found a correlation between energy use and GDP. In developed countries, the authors evaluated a bidirectional relationship between GDP and energy use. In developing nations, a one-way relationship was observed. They suggest that policies aimed at limiting energy use do not have any negative effect on production in the developing nations. Furthermore, Hasanov et al. (2017) also addresses on the subject in the period between 1997 and 2014 in ten Eurasian countries and using the GMM and Granger causality. They concluded that causality exists between energy use and GDP thus reducing the rate at which energy is used has a negative impact on production activities. Another study by Tang and Abosedra (2014) evaluated tourist activities, energy use and political issues in twenty-four nations located in the Middle East and Northern region of Africa. The researchers relied on static and dynamic methods to verify the affiliation between the variables. They concluded that energy use had a positive impact on economic development. Nayan et al. (2013) focused on assessing how energy use and the rate at which an economy develops relate to each other? They concluded that the variables had a one-way relation controlled by GDP and energy use.

More recently, Amaefule et al. (2022) investigates the pairwise causality and cointegration that links carbon dioxide (CO_2)

emissions, and real gross domestic product (RGDP) between low-income countries (LIC) and high-income countries (HIC) during the period 1960 and 2019. Their results reveal a unidirectional causality: the RGDP granger causes CO_2 in HIC, and no causality between RGDP and CO_2 in LIC. They recommend that to achieve a low carbon economy and a high growth regime, the global community should adopt a techno-economic paradigm model that would accelerate growth within a low-carbon economy regime to realize the 45% carbon reduction target by 2030 and the 2050 net-zero emission target. Another study by Wahyudi et al. (2023) recommend that policy that consist in paying attention to environmental sustainability, as well as carrying out energy transformation results in reducing the spread of CO_2 and help therefore LIC to become upper -middle or even high-income countries.

The various literature review studies have been conducted with a focus on the different issues that this study attempts to address. Even though a lot of empirical research indicates that there subsists an association between economic development and energy usage, their findings have not been conclusive. This results from the fact that researchers apply varying research designs, sample sizes and conduct their research at different times. Despite the variation in findings, the researchers agree that there is a need for binding decisions which are necessary to increase the standards of living for upcoming generations. This study contributes to the existing literature by providing a new empirical investigation and tackling the previous literature gap.

3. DATA AND METHODOLOGY

In order to study the association that exists among a number of energy-related variables such as energy use, renewable energy use, carbon pollutants and the economic growth of European Union countries, we use three stage procedure. In the first stage, unit root test is adopted to check stationarity of the data. In the second stage, the cointegration test is done. In the final stage, the Panel Vector Error Correction Model was applied to check relationship among the variables. The steps are mentioned below in detail. Figure 1 represents methodological flow of the study.

3.1. Data

Data used in this research study was from twenty-four EU member states that are major energy consumers during the period of our study, 2000-2020. All the data variables came from the World Bank Database (2020), World Development Indicators. The variables of interest are carbon emission (metric tons per capita), energy consumption (kg of oil equivalent per capita), Gross Domestic Product (per capita current US $) and renewable energy consumption (total electricity output in percentage). For empirical analyses, the data cleaning procedure were adopted. To make it more clear, conceptual hypothetical framework represent in the Figure 2. At few points, the unavailable data was computed by taking an average of last three years to assume that there is no significance change for the computed years.

The study attempts to evaluate the impact of energy use on the rate of carbon released to the atmosphere and on GDP in twenty-four EU countries. The analysis depends on the following equation:

Figure 1: Methodological flow of the study

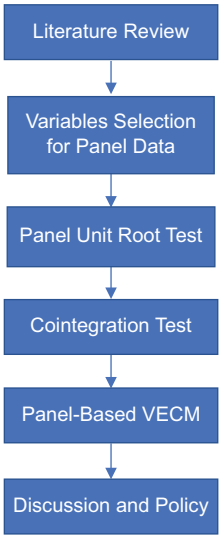
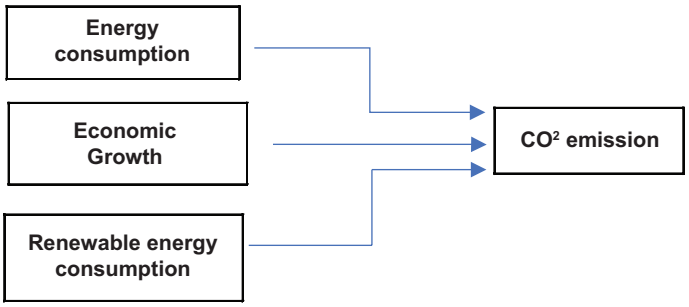


Figure 2: Conceptual hypothetical framework of the study



$$CEM=f(ENR, GDP, REN) \quad (1)$$

Where, CEM represents carbon released to the atmosphere, ENR refers to energy use and REN represents renewable energy consumption. GDP is a proxy for economic development.

3.2. Methodology

An estimation strategy of this paper is as follows-

3.2.1. Panel Unit Root Test

When conducting any research, it is essential to evaluate the stationarity of involved variables. In a case whereby there is a limited temporal dimension, the procedure used follows "the panel stationarity test" to identify integration order of variables with a focus on level and first difference (Dickey and Fuller, 1979). "The panel unit root test" helps to determine whether there exists a unit root when generating data. LLC, ADF and PP unit root tests play a role in identifying integration order which utilizes structural breaks in data series. The statistics indicated in Table 1 show that each of the variables have a unit root. At the first difference all the variables were stationary.

3.2.2. Panel cointegration test

After checking the stationarity level of the variables, second stage required to check the relationship among the variables i.e.

Table 1: Panel unit root test results

Variables	LLC		ADF		PP	
	Level	First degree	Level	First Degree	Levels	First Degree
CEM	−5.86060 (0.0000)	−17.7649*(0.0000)	96.9972 (0.0000)	348.841*(0.0000)	96.7849 (0.0000)	435.927* (0.0000)
ENG	−4.12095 (0.0000)	−22.7352* (0.0000)	72.1596 (0.0136)	427.854* (0.0000)	66.7216 (0.0381)	480.584*(0.0000)
GDP	5.62203 (1.0000)	−15.2204* (0.0000)	3.91817 (1.0000)	280.352* (0.0000)	4.21216 (1.0000)	284.377* (0.0000)
REN	6.93447 (1.0000)	−13.0696* (0.0000)	4.30510 (1.0000)	272.420* (0.0000)	2.24673 (1.0000)	322.483*(0.0000)

LLC: Levin, Li and Chu, ADF: Augmented Dickey-Fuller, PP; Phillips-Perron, CEM: Carbon emission, ENR: Energy consumption, GDP: Gross domestic product, REN: Renewable energy consumption. * Represent significance at 1%. (0.01)

cointegration test. Johansen Fisher cointegration test was applied to test more than one cointegration at one time. The decision criteria were based on the value of two test statistics- Trace test and Max-Eigen test. The acceptance and rejection depend upon the corresponding probability value at 0.05 test levels. The result of panel cointegration test is shown in Table 2.

3.2.3. Panel causality test result

After cointegration test, the third stage requires to check the direction of causality among the variables. This research study utilizes the panel based VECM model to evaluate the direction of an equilibrium relationship over a long period.

Further, to analyze the relationship among the variables, we have developed an initial equation;

$$CEM_{it}=\alpha_{it} + \beta_{1it}ENR + \beta_{2it}GDP + \beta_{3it}REN + \varepsilon_{it} \quad (2)$$

Where CEM, ENR, GDP and REN stand for carbon emission, energy consumption, gross domestic product and renewable energy consumption respectively. α is intercept term, ε_{it} shows residual with time and countries.

The VECM model can be written with used variables as follows:

$$\Delta CEM= \alpha_1 + \sum_{t=1}^{k-1} \beta_{1it}\Delta CEM_{it-k} + \sum_{t=1}^{k-1} \beta_{1it}\Delta ENR_{it-k} + \sum_{t=1}^{k-1} \beta_{1it}\Delta GDP_{it-k} + \sum_{t=1}^{k-1} \beta_{1it}\Delta REN_{it-k} + \lambda_{1i}ECT_{t-1} + \varepsilon_{1it} \quad (3)$$

$$\Delta ENR= \alpha_2 + \sum_{t=1}^{k-1} \beta_{2it}\Delta CEM_{it-k} + \sum_{t=1}^{k-1} \beta_{2it}\Delta ENR_{it-k} + \sum_{t=1}^{k-1} \beta_{2it}\Delta GDP_{it-k} + \sum_{t=1}^{k-1} \beta_{2it}\Delta REN_{it-k} + \lambda_{2i}ECT_{t-1} + \varepsilon_{2it} \quad (4)$$

$$\Delta GDP= \alpha_3 + \sum_{t=1}^{k-1} \beta_{3it}\Delta CEM_{it-k} + \sum_{t=1}^{k-1} \beta_{3it}\Delta ENR_{it-k} + \sum_{t=1}^{k-1} \beta_{3it}\Delta GDP_{it-k} + \sum_{t=1}^{k-1} \beta_{3it}\Delta REN_{it-k} + \lambda_{3i}ECT_{t-1} + \varepsilon_{3it} \quad (5)$$

$$\Delta REN= \alpha_5 + \sum_{t=1}^{k-1} \beta_{5it}\Delta CEM_{it-k} + \sum_{t=1}^{k-1} \beta_{5it}\Delta ENR_{it-k} + \sum_{t=1}^{k-1} \beta_{5it}\Delta GDP_{it-k} + \sum_{t=1}^{k-1} \beta_{5it}\Delta REN_{it-k} + \lambda_{5i}ECT_{t-1} + \varepsilon_{5it} \quad (6)$$

Where, ECT_{t-1} is the lagged error correction term, Δ shows first difference, λ is speed of adjustment, k-1 is lag length (reduced by one), β is short run dynamic coefficient of the model adjustment

Table 2: Johansen fisher cointegration test result

Hypothesized number of cointegration equation	Trace statistics	Probability value	Maximum Eigen statistics	Probability value
None*	303.3	0.0000	189.4	0.0000
At most 1	151.7	0.0000	94.58	0.0001
At most 2	87.40	0.0004	60.86	0.1008
AT most3*	63.44	0.0669	63.44	0.0669

*shows rejection of null hypotheses at 0.05 test level. This test is based on Chi-square distribution

long run equilibrium and ε_{it} is residuals, i and t show countries and time period respectively. The VECM causality results are reported in Table 3.

The short run causality derived from dependent and independent variables whereas long run causality from the ECT (-1) statistics. Short run relationship is noted from renewable energy consumption to energy consumption and carbon emission; from economic growth to energy consumption; and carbon emission to economic growth. Long run relationship exists with energy consumption and carbon emission with all the variables shown by the ECT (−1) values.

4. RESULTS AND DISCUSSION

The discussion is based upon VECM result shown in the Table 3. The short run results show, that renewable energy consumption is significantly related with energy consumption and carbon emission (Bilgili et al., 2016; Lu, 2017). It indicates that as nation grows significantly, it uses more energy to both production and consumption purposes that leads to emission problem which alarms the environmental and sustainability issues. A large proportion of energy is derived from traditional sources of energy that result more carbon emission in the environment. Such issues motivate the energy producers to focus on the clean sources of energy to produce and supply. on the other hand, energy consumers are required to shifts from traditional to modern energy sources. Renewable sources of energy show an important alternative that fulfills twin objectives of energy requirement and mitigation of carbon emission. The Government tries to motivates to use renewable energy with the provision of measure, such as tax incentives in the renewable energy production and consumption, carbon free transport norms to promote electric vehicles that consists large portion of energy consumption and carbon emission and, domestic as well as foreign investment with research and development in the development of new renewable energy sources within the country.

Table 3: Panel causality test results based on VECM

Dependent variables	Independent Variables (Short run)				ECT (-1) Long run
	CEM	ENR	GDP	REN	
CEM	-	0.4564 (0.7448)	0.1347 (−1.4963)	0.0062*** (−2.7395)	0.0001*** (−3.9482)
ENR	0.1697 (1.3736)	-	0.0001*** (−3.8850)	0.0527* (−1.9389)	0.0140** (−2.4586)
GDP	0.0214** (2.3036)	0.3718 (0.8932)	-	0.9164 (0.1049)	0.0000 (6.2031)
REN	0.4824 (−0.7026)	0.7925 (−0.2630)	0.7274 (0.3485)	-	0.0759 (1.7761)

- P values and t statistics (in brackets). * Shows significant at 10%, (0.10)** shows significant at 5%, (0.05) *** shows significant at 1% (0.01). Lag length selection is based on the Schwarz information criterion

Unidirectional relationship is noted from economic growth to energy consumption in the short run. It indicates that economic growth leads to energy consumption to run production and consumption activities. The sectoral composition of an economy become thrust area to earn profits and supply as per the requirement in the economy. A constant supply of energy in the both industrial and domestic purposes target to increase income and welfare of the society. Thus, smooth flow of energy supply primarily clean energy become the crucial motive for the national as well as international entities to focus on the new sources of energy to run the economy and moves to the development path. A possible influence of economic growth could be assumed in the domestic sector to use energy saving and energy efficient appliances that further boost investment in durable goods industries to make sure energy efficient technology in the production purposes.

Further, carbon emission is associated with economic growth in the short run. It implies that, as production activities goes on, more energy is consumed to run industries to production of goods and a constant supply of energy in the economy to make continuous profit. The basic energy sources are traditional in nature which are easily arrange from either extraction or imports. The limit of carbon emission may be compromise to economic growth that could impacts negatively in the economy and its sectors. At this stage, the environmental measure became important consideration which tries to motivates to reduce carbon emission with the continuation of economic growth with a significant number. Sustainability measures such as, carbon sequestration techniques, technological advancement, efficient production techniques etc. become focus areas for the government, policymakers and organizations.

Apart from this, the long run relationship exists between carbon emission, energy consumption economic growth and renewable energy consumption (Bilan et al., 2019; Bekun et al., 2019).It implies that growing nation is highly depends upon the energy consumption which directly supports carbon emission with significantly. Energy requirement motivates to focus on the development of alternative sources of energy. Tax incentives, feed in tariff and incentive prices are motivation regulatory measure for the renewable energy produces to promote its production. Moreover, investment in renewable energy sources become crucial which requires financing facilities and fund-raising activities both national and international level. Energy support policies such as, green financing and credit facilities is the focus area to facilitate long term financing in the clean energy sector.

Even though enhanced energy use contributes significantly to economic development as indicated in the findings, there is a need to establish limits and policies that will help to minimize carbon emissions. Afonso et al. (2019) stated possible strategies at demand side of management, e- mobility of energy generation and consumption and, implementation of minimum quota provision for the renewable energy promotion.

Increased use of energy stimulates production activities which support economic growth. However, the use of non-renewable sources of energy has significant negative impacts to the environment through carbon emissions. This indicates a great need to establish policies that promote the renewable energy sources usage. This will help to ensure that production activities necessary for economic development do not face interruption. Renewable energy usage will help to stimulate economic growth while also preserving the environment through reduced carbon emissions.

5. CONCLUSION

This research study evaluates the effect that energy use and economic development have on CO_2 emissions in EU member states from 2000 to 2020. The empirical findings from this research indicate that our variables of interest are associated to each other over a short and long period. It is noticed that carbon emission is influenced with economic growth in the short and the long run. This shows that the energy consumption is high in the investigated region which enables maintaining the pace of economic growth and any compromise to reduce the energy consumption become hinderance to the development. Energy use has a significant stimulus on the level of CO_2 emissions and on the rate at which economies grow a in the short run CO_2 emissions have proved to be a challenge to European nations as a result of increased energy use. This has forced them to replace fossil fuels with energy sources that are safe for humans and the environment. One solution is to adopt clean energy development and production of energy from renewable sources. This requires governments to establish policies and measures that should help to curb environmental pollution while also enhancing economic development. European nations should pay attention to the use of energy from renewable sources to ensure the ongoing of production which are necessary to stimulate economic growth. Renewable sources of energy will help to reduce the rate of carbon emissions to the atmosphere while also facilitating various production activities. A significant piece of the EU environmental change strategy is the expense adequacy of approaches and measures. This suggests a combination of measures for the six gases that might have the littlest sum as an incentive for all areas alone. It should be noticed that except for cost-viability, various standards for decision and execution of measures additionally are essential, as political agreeableness,

decency (for instance between areas), social boundaries, and modern forcefulness. Utilization of all decrease means with a cost under fifty euros/ton ozone depleting substance.

This study has several limitations. First, the study only indicates an association between energy usage and economic growth but does not include other factors influencing the relationship. For instance, trade is a vital factor which is susceptible to significantly influence both economic growths and carbon emission. The study only cites production as a factor that influences the relationship between the two variables. This indicates a great need to identify several factors that alter the relationship. Evaluating the different factors should help to enhance an understanding of how the variables are related and how to be controlled. It would also help to inform policies that can ensure the use of safe energy while also stimulating economic growth.

Further limitation is the time period that taken from 2000 to 2020 where the impact of the Covid19 pandemic in the economic performance has not been considered in the study. This also influences the energy consumption of both household and industrial sectors, since the pandemic has affected the trade pattern due to lockdown globally.

Future research studies should focus on the relationship between energy use and economic development to identify other factors that are determinants to the above relationship. The current research only highlights production as one of the main factors while there is a great need to identify the other factors. Existing studies indicate that a relationship exists between the two variables but do not focus on the factors that affect it. Identifying more factors that have an influence on the relationship will help to promote better understanding of the topic which is necessary to establish limits that protect the environment from pollution. Globally, developing nations are now on the central point of discussion to influence economic growth and carbon emission which should be on the interest of future study. The development of renewable energy sources is on a great attention to combat carbon emission. This is further possible through focus on the energy storage and transmission feasibility. The inclusion of storage and grid feasibility either in stand-alone or grid transmission supply will also be covered in the future. Moreover, the study on battery storage and electric vehicle is on the need for future researchers.

REFERENCES

Amaefule, C., Kalu, I.E., Udeorah, S., Ebelebe, L.O. (2022), Fossil fuel consumption, CO2 emissions and growth in high-income countries and low-income countries. European Journal of Sustainable Development Research, 6(3), em0190.

Apergis, N., Payne, J.E. (2012), Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. Energy Economics, 34(3), 733-738.

Apergis, N., Tang, C.F. (2013), Is the energy-led growth hypothesis valid? New evidence from a sample of 85 countries. Energy Economics, 38, 24-31.

Avazkhodjaev, S., Usmonov, J., Bohdalová, M., Lau, W.Y. (2022), The causal nexus between renewable energy, CO2 emissions, and economic growth: New evidence from CIS countries. International Journal of Energy Economics and Policy, 12(6), 248-260.

Bekun, F.V., Alola, A.A., Sarkodie, S.A. (2019), Toward a sustainable environment: Nexus between CO2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. Science of the Total Environment, 657, 1023-1029.

Bilan, Y., Streimikiene, D., Vasylieva, T., Lyulyov, O., Pimonenko, T., Pavlyk, A. (2019), Linking between renewable energy, CO2 emissions, and economic growth: Challenges for candidates and potential candidates for the EU membership. Sustainability, 11(6), 1528.

Bilgili, F., Koçak, E., Bulut, Ü. (2016), The dynamic impact of renewable energy consumption on CO2 emissions: A revisited Environmental Kuznets Curve approach. Renewable and Sustainable Energy Reviews, 54, 838-845.

Bölük, G., Mert, M. (2014), Fossil and renewable energy consumption, GHGs (greenhouse gases) and economic growth: Evidence from a panel of EU (European Union) countries. Energy, 74, 439-446.

Chontanawat, J. (2020), Relationship between energy consumption, CO2 emission and economic growth in ASEAN: Cointegration and causality model. Energy Reports, 6, 660-665.

Coers, R., Sanders, M. (2013), The energy-GDP nexus; addressing an old question with new methods. Energy Economics, 36, 708-715.

Destek, M.A., Aslan, A. (2017), Renewable and non-renewable energy consumption and economic growth in emerging economies: Evidence from bootstrap panel causality. Renewable Energy, 111, 757-763.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366a), 427-431.

Gielen, D., Boshell, F., Saygin, D., Bazilian, M.D., Wagner, N., Gorini, R. (2019), The role of renewable energy in the global energy transformation. Energy Strategy Reviews, 24, 38-50.

González, P.F., Landajo, M., Presno, M.J. (2014), Tracking European Union CO2 emissions through LMDI (logarithmic-mean Divisia index) decomposition. The activity revaluation approach. Energy, 73, 741-750.

Hasanov, F., Bulut, C., Suleymanov, E. (2017), Review of energy-growth nexus: A panel analysis for ten Eurasian oil exporting countries. Renewable and Sustainable Energy Reviews, 73, 369-386.

Kraft, J., Kraft, A. (1978), On the relationship between energy and GNP. The Journal of Energy and Development, 3, 401-403.

Lee, C.C., Chang, C.P. (2007), Energy consumption and GDP revisited: A panel analysis of developed and developing countries. Energy Economics, 29(6), 1206-1223.

Lu, W.C. (2017), Renewable energy, carbon emissions, and economic growth in 24 Asian countries: Evidence from panel co-integration analysis. Environmental Science and Pollution Research, 24(33), 26006-26015.

Mahmood, T., Ahmad, E. (2018), The relationship of energy intensity with economic growth: Evidence for European economies. Energy Strategy Reviews, 20, 90-98.

Nayan, S., Kadir, N., Ahmad, M., Abdullah, M.S. (2013), Revisiting energy consumption and GDP: Evidence from dynamic panel data analysis. Procedia Economics and Finance, 7, 42-47.

Okyay, U.C.A.N., Aricioglu, E., Yucel, F. (2014), Energy consumption and economic growth nexus: Evidence from developed countries in Europe. International Journal of Energy Economics and Policy, 4(3), 411-419.

Ouedraogo, N.S. (2013), Energy consumption and economic growth: Evidence from the economic community of West African States (ECOWAS). Energy Economics, 36, 637-647.

Purnomo, S.D., Wani, N., Suharno, S., Arintoko, A., Sambodo, H., Badriah, L.S. (2023), The effect of energy consumption and renewable energy on economic growth in Indonesia. International Journal of Energy Economics and Policy, 13(1), 22-30.

Radmehr, R., Henneberry, S.R., Shayanmehr, S. (2021), Renewable energy consumption, CO2 emissions, and economic growth nexus: A simultaneity spatial modeling analysis of EU countries. Structural Change and Economic Dynamics, 57, 13-27.

Rasool, S.V, Chin, T., Wang, M., Asghar, A., Khan, A., Zhou, L. (2022), Exploring the role of organizational support, and critical success factors on renewable energy projects of Pakistan. Energy, 243, 122-765.

Saidi, K., Omri, A. (2020), The impact of renewable energy on carbon emissions and economic growth in 15 major renewable energy-consuming countries. Environmental Research, 186, 109567.

Smolović, J.C., Muhadinović, M., Radonjić, M., Đurašković, J. (2020), How does renewable energy consumption affect economic growth in the traditional and new member states of the European Union? Energy Reports, 6, 505-513.

Surya, B., Salim, A., Suriani, S., Menne, F., Rasyidi, E.S. (2021), Economic growth and development of a Minapolitan area based on the utilization of renewable energy, Takalar regency, South Sulawesi, Indonesia. International Journal of Energy Economics and Policy, 11(5), 255-274.

Tang, C.F., Abosedra, S. (2014), The impacts of tourism, energy consumption and political instability on economic growth in the MENA countries. Energy Policy, 68, 458-464.

Wahyudi, H., Suripto, S., Palupi, W. (2023), Long-term implications of economic complexity and energy intensity on the environment in lower-middle-income countries in Asia. International Journal of Energy Economics and Policy, 13(1), 164-171.