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Review

Toward Understanding Renewable Energy and Sustainable Development in Developing and Emerging Economies: A Review

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Abstract: The last few years have witnessed an explosion of research on Sustainable development. Most of this research is concentrated on the developed countries related to the issues not compatible with developing countries. This paper fills the gap and reviews the literature related to developing and emerging economies and their environmental and social constraints under Renewable energy and sustainable development (RESD). It also investigates how RESD can be implemented in the presence of serious issues pertaining to population increase, shortage of energy supply, lack of transportation, shortage of clean water, less food production and bad environmental systems and these are coupled with war, and hunger and political instability. The main contribution of this paper is to present extensive discussion in the context of hypotheses of economic growth and its association with energy consumption, and renewable energy options for sustainable development.

Keywords: emerging economies; economic development; renewable and sustainable energy

1. Introduction

The last few years have witnessed an explosion of research on Sustainable development. Energy is a prerequisite for development and sustainable energy systems are a prerequisite for sustainable development (Østergaard and Sperling, 2014). While the developed world has seen rapid development over particularly the last decade with penetration levels of renewable energy sources reaching double-digit percentages in electricity supply in several countries, many other developing countries are still only at an introductory level in terms of renewable penetration (Østergaard et al., 2020).

In fact, in recent times non-renewable energy remains the most used energy resource in the developing world. It provides more than 87 percent of the primary energy use (Gyimah et al., 2022). Fossil fuels and other sources of non-renewable energy generate CO_2 emissions as a byproduct. Since non-renewable fuels are the primary source of pollution, several countries have attempted to improve their manufacturing processes and energy use in the wake of recent disasters. Some countries have mostly abandoned fossil fuels in favour of renewable sources, while many others still use fossil fuels as the main source of energy (Irfan et al., 2021). Indeed, the majority of energy extraction in developing countries comes from fossil fuels, with less than 20% coming from renewable sources (Larcher and Tarascon, 2015). Developing countries face a major challenge when it comes to renewable energy investment (Ram et al., 2018; Inal et al., 2022).

The empirical literature on the association between energy consumption and economic growth is enormous, and it has been growing, especially after the influential work of Kraft and Kraft (1978) on the USA economy. The research extended to many countries

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of the world for different data periods with various adopted methodological approaches. The results obtained are much diversified, and there is a lack of agreement among the researchers not only on the existence of the relationship but also on the direction of causality between the two variables (Acheampong et al., 2021; Chen et al., 2022; Wang et al., 2022).

Given the importance and growth of renewable energy, it is vital to realise the dynamic links between renewable energy consumption and economic growth for contributing to the literature on energy economics and sustainable energy future. The main objective of this review article is to assess the connection between renewable energy, energy consumption, and sustainable development in both developing and developed economies around the world.

2. Renewable Energy and Economic Growth

Researchers dispute the relationship between expanding the usage of renewable energy sources and stimulating the economy. From this perspective, the connection between economic growth and biomass energy use in developing countries was investigated by Konuk et al. (2021). Their outcomes suggest that biomass energy usage and economic growth go hand in hand. The review study by Jenniches (2018) also looked at the economic implications of a shift to generate renewable energy sources in the region. Determining technologies and timeframes for evaluation are critical, in his opinion. Doytch and Narayan (2021) examine the impact of manufacturing and service growth on the usage of non-renewable and renewable energy sources. According to their findings, high-growth industries such as the service industry in advanced economies as well as the manufacturing industry in developing economies benefit from renewable energy. Acheampong et al. (2021) find a two-way causal association between economic growth and renewable energy using the GMM-PVAR approach. Koengkan et al. (2020) discover that countries such as Venezuela and Argentina have low levels of renewable energy in their power mix. These governments saw a connection between renewable energy and fossil fuel usage as a viable solution to resource shortages.

Instead of increasing economic growth in several countries, energy conservation measures might slow it down (Soytas and Sari, 2003). Another study by Ivanovski et al. (2021) suggests a positive impact of non-renewable energy on economic activity and development in OECD countries. Zebra et al. (2021) investigate renewable energy systems in developing nations. With regards to renewable and nonrenewable mini-grid maintenance and production, Asian developing countries surpass African countries. As mini-grid costs come down, renewable energy will become increasingly more accessible on the utility-scale. Researchers also examine the contradictory connection between economic growth (hurdles) and renewable energy production. Although Seetharaman et al. (2019) agree that technological, sociological, and governmental barriers to renewable energy development exist, they claim that such factors do not directly affect the result of renewable energy.

Islam et al. (2022) discover that the consumption of renewable energy consumption does not impede economic growth, however, it plays a significant role in stifling economic growth. Income growth has both good and adverse effects on both renewable and nonrenewable energy use considering the positive impact of both domestic and international investments on renewable and non-renewable energy consumption. In addition, the use of renewable energy is influenced positively by the quality of the institution. Urbanization, on the other hand, has a detrimental impact on renewable energy consumption since it has a positive impact on non-renewable energy consumption. To achieve faster and more stunning economic growth, certain industrialised countries, despite their revolutionary attempts to embrace renewable energy technology, remain tied to the usage of fossil fuel alternatives (Shrinkhal, 2019). Even while renewable energy has an environmental benefit, the economic peace that may be achieved with non-renewable sources of energy benefits different economies and the way of life of their citizens, but it does not

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benefit the environment. For industrialised countries, renewable energy consumption may not have a substantial impact on economic growth. In several EU nations, there may be no correlation between RE and economic development metrics. There has been some discussion and an uncertain economic climate, but the EU countries' proportion of overall energy consumption is steadily increasing and is not greatly dependent on economic issues (Ogonowski, 2021). Renewable energy may have a significant economic impact if only nuclear and fossil fuels were substituted. South Korea's electricity and power generation would have to pay an additional 35 trillion KRW per year if only renewable energy sources were used (Park et al., 2016). Customers will be unwilling to pay for this strategy since it is impractical. Lema et al. (2021) attempt to quantify the direct and indirect economic effects of investments in renewable energy projects by conducting a comprehensive analysis. According to their findings, the FDI and investments in renewable energy projects may have "economic advantages" for the region by establishing new job and training possibilities, production and linking activities, and so on. For the region's renewable energy resources to be fully utilised, education and mobilisation of the general public are also imperative. According to Oluoch et al. (2020), 73 percent of Kenyans highly support the development of renewable energy sources technologies, and 91 percent feel that renewable energy technologies will lower the cost of power generation in the country.

Numerous studies in the fields of theory and research suggest that the relationship between rising economic activity and rising energy consumption might take several different forms. Recent economic studies on renewable energy sources and long-term economic development are necessary for light of the growing public concern over the environmental harm caused by fossil fuel use. For example, the growth, conservation, feedback, and neutrality hypotheses are only a few examples of theories that have been proposed to explain the energy consumption–economic growth connection. Table 1 summarises the causality between renewable energy consumption and economic growth. Overall, this review suggests the great variety of empirical models used in these studies has led to inconclusive results.

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Table 1. Key findings of the relationship between renewable energy and economic growth.

Authors	Period	Countries	Methodology	Main Result
Apergis and Payne (2011)	1980–2006	Six Central American countries	Panel error correction model	Bidirectional causality between renewable energy and economic growth.
Menegaki (2011)	1997–2007	27 European countries	Random effect model	No causality between renewable energy consumption and GDP.
Apergis and Payne (2012)	1990–2007	80 countries	Panel error correction model	Bidirectional causality between renewable energy and economic growth.
Vaona (2012)	1861 to 2000	Italy	Granger causality tests	No causal relationship between real GDP and energy consumption.
Yildirim et al. (2012)	1960–2010	United States	Toda-Yamamoto causality tests	No causal relationship between real GDP and all renewable energy kinds.
Ocal and Aslan (2013)	1990-2010	Turkey	ARDL approach	Economic growth to renewable energy consumption.
Pao and Fu (2013)	1980-2010	Brazil	Johansen cointegration test	Unidirectional causality from renewable energy to economic growth.
Al-Mulali (2014)	1990–2010	30 major nuclear energy-consuming countries	Pedroni co-integration test	Energy consumption has a positive long-run effect on GDP growth.
Ozturk and Bilgili (2015)	1980–2009	51 Sub-Sahara African countries	Panel cointegration analyses	Biomass consumption affects economic growth.
Alper and Oguz (2016)	1990–2009	New EU member countries	Causality test approach	Renewable energy has positive impacts on economic growth
Bhattacharya et al. (2016)	1991-2012	38 countries	Panel cointegration test	Renewable energy has a positive impact on the economic output.
Inglesi–Lotz (2016)	1990 - 2010	OECD countries	Panel cointegration technique	Renewable energy consumption has a positive effect on economic growth.
Kahia et al. (2017)	1980–2012	MENA Net Oil Importing countries	Panel error correction model	Bidirectional causality between renewable energy use and economic growth.
Chen et al. (2020)	1995-2015	103 countries	GMM and threshold estimation methods.	Renewable energies have a favourable impact on economic growth in OECD, but not in developed ones.
Rahman and Velayutham (2020)	1990–2014	South Asian countries	Long-run co-integration tests	Renewable energy has a positive impact on economic growth.
Wang and Wang (2020)	2005 to 2016	OECD countries	Panel threshold regression models	The impact of renewable energy on economic growth is positive.
Acheampong et al. (2021)	1960–2017	Sub-Saharan Africa	GMM-PVAR approach	A two-way causal association between economic growth and renewable energy.
Armeanu et al. (2021)	1990–2014	106 countries	Granger causality test	Unidirectional and bidirectional causal identified.
Doytch and Narayan (2021)	1984 - 2019	107 countries	System GMM	Renewable energy enhances growth in high-growth sectors
Konuk et al. (2021)	1970-2017	11 Developing countries	Panel causality test	Bi-directional causality between biomass energy and growth.
Li and Leung (2021)	1985–2018	Seven European countries	Panel cointegration and long-run causality	GDP impacts renewable energy consumption.
Namahoro et al. (2021a)	1980 - 2016	Lower and middle-income countries	(CS-DL and CCEMG) approaches	The positive influence of renewable energy on economic growth.
Namahoro et al. (2021b)	1990-2015	Rwanda	NARDL and causality tests	Renewable energy consumption negatively affects growth in the long term.
Sharma et al. (2021)	1990 - 2016	27 European countries	Arellano-Bond dynamic panel data estimation	Two-way negative causality between growth and renewable energy.
Aslan et al. (2022)	1990–2015	20 countries	Panel VAR (PVAR) and Granger causality methods	Bi-directional causality between renewable energy and economic growth.
Chen et al. (2022)	1996 - 2019	Norway, New Zealand, and two	(MS-VAR) model	Unidirectional causal link from economic growth to renewable energy

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		Canadian provinces		is found in the case of New Zealand, Alberta, and Ontario
Eyuboglu and Uzar (2022)	1990 - 2015	15 emerging countries	Bootstrap panel causality test	No causal relationship between renewable energy and economic growth.
Gyimah et al. (2022)	1990 - 2015	Ghana	Granger causality test	Bi-directional causality between renewable energy and economic growth.
Kuo et al. (2022)	1995 - 2019	10 Asian countries	CS-ARDL approach	Renewable energy contributes to economic development
Inal et al. (2022)	1990– 2014	African oil-producing countries	Bootstrap panel LM cointegration	No causal relationship between renewable energy and economic growth.
Islam et al. (2022)	1990– 2019	Bangladesh	Dynamic ARDL (DARDL) model	Economic growth promotes renewable energy consumption.
Mohsin et al. (2022)	1990 - 2018	The West African States	DEA approach	Renewable energy has a positive impact on growth.
Mukhtarov (2022)	1992 - 2015	Azerbaijan	The Toda-Yamamoto causality test	Unidirectional causal link from economic growth to renewable energy consumption.
Murshed et al. (2022)	1971 - 2016	Argentina	An augmented version of the STIRPAT model	Long-run associations between renewable electricity generation and economic growth
Steve et al. (2022)	1990 – 2018	Sub-Saharan Africa	Dumitrescu-Hurlin Granger causality	An increase in renewable energy consumption led to a reduction in economic growth
Slusarczyk et al. (2022)	1991 - 2022	Poland and Sweden	A regression model	Economic growth causes more renewable energy consumption.
Wang et al. (2022)	1997 - 2015	OECD countries	A panel threshold model	The impact of renewable energy consumption on economic development
Wang et al. (2022)	2002 - 2018	114 countries	FOLS model and threshold model.	The impact of renewable energy on the economy varies across income groups.
Zhao et al. (2022)	2003 - 2018	286 Chinese cities	A spatial econometric model	U-shaped non-linear effect of energy efficiency and green economic growth.

2.1. Growth Hypothesis

The growth hypothesis argues that energy consumption is critical to economic growth, and other inputs (such as technological advancement, capital investment, and labour) cannot substitute for the importance of energy in the production process. According to this theory, a reduction in energy usage could have a negative impact on economic growth. Bhattacharya et al. (2016) conclude that in 57 percent of the countries studied, the use of renewable energy has a "substantial positive influence" on long-term economic growth, using panel estimating methodologies for the 38 leading renewable energy-producing countries from 1990 to 2012. Therefore, renewable energy use is a significant contributor to economic growth. Using the Pedroni co-integration method, Inglesi–Lotz (2016) investigate 34 OECD nations between 1990 and 2010. Results show that renewable energy consumption has a positive effect on economic growth. Recently, Murshed et al. (2022) examine the causal relationship between renewable energy consumption and economic growth in the case of Argentina over the period 1971-2016. Using an Augmented version of the STIRPAT model, they find a long-run association between renewable energy and economic growth. In addition, Wang et al. (2022) use a panel of OECD countries to investigate the causal relationship between renewable energy and economic growth. The study finds that the impact of renewable energy consumption on economic development is positive.

2.2. Feedback Hypothesis

The feedback hypothesis claims that the amount of energy consumed is directly linked to economic growth. These two factors are intertwined, according to this theory. In recent years, new research has been slow in backing up the feedback concept. Renewable energy use and economic growth were found to have a bidirectional causality for Sub-Saharan Africa between 1960 and 2017 discovered by Acheampong et al. (2021). More recently, similar findings are also reported by Aslan et al. (2022) for 20 developed and

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developing countries Gyimah et al. (2022) for the case of Ghana and Murshed et al. (2022) for the case of Argentina.

2.3. Conservation Hypothesis

According to the conservation theory, energy consumption is a function of economic growth. The growth concept is absolutely at odds with this one (e.g., energy consumption determines economic growth). The hypothesis of conservation has had a great deal of support in recent years. Between 1994 and 2003, Sadorsky (2009) employs panel co-integration estimations for a sample of 18 emerging economies to investigate the relationship between renewable energy use and economic growth. Results indicate that economic growth has a positive influence on renewable energy consumption. The author reports that renewable energy consumption would surge by 3.5 percent if real GDP per capita increased by 1 percent. This means that renewable power consumption will increase dramatically as emerging economies gain traction. Menyah and Wolde-Rufael (2010), for example, find evidence of one-way causality between GDP growth and the utilisation of renewable energy in the United States. Conservation theory was also validated by more recent studies (see e.g., Chen et al., 2022; Islam et al., 2022; Slusarczyk et al., 2022).

2.4. Neutrality Hypothesis

According to the theory of neutrality, there is no correlation between the consumption of energy and the growth of the economy. Researchers indicate that energy has little bearing on economic growth. Capital and labour are the basic components of production, while energy is an intermediate input. Despite a multitude of evidence indicating a connection between the use of renewable energy and economic growth, other investigations have shown no such connection is existed in many European countries (Menegaki, 2011). Since renewable energy was still in its infancy in Europe during this period, Menegaki (2011) has proposed that the lack of correlation between GDP growth and renewable energy usage may be attributable to this early stage of development and market penetration. Toda-Yamamoto causality tests were conducted on the US economy from 1949 to 2010 by Yildirim et al. (2012). The study supports the neutrality hypothesis, that is, no casual association between economic growth and renewable energy use. Vaona (2012) uses Granger's causality tests to confirm the presence of the neutrality hypothesis in Italy for the years 1861 to 2001. More recent studies support this hypothesis. For instance, using a bootstrap panel causality test, Eyuboglu and Uzar (2022) find that there is no causal relationship between renewable energy consumption and economic growth for a panel of 15 emerging countries over the period 1990 –2015. Similar findings are also reported by Inal et al. (2022) for the case of African oil-producing countries from 1990 through 2014.

Therefore, the literature here shows no clear evidence of a link between increased use of renewable energy sources and increased economic growth in any direction or form.

3. Renewable Energy and Economic Growth in Developed Countries

Despite their economic success, the G7 industrialised countries are unable to ensure environmental sustainability. Using panel data to determine the environmental impact of specific factors, financial globalisation and eco-innovation have been shown to lower the ecological footprint. Urban areas have a negative impact on the environment because they increase carbon footprint levels (Ahmad et al., 2021). Amri (2017) emphasises the interconnectedness of three parameters across various income groups of countries. Renewable energy use and GDP growth, commerce and renewable energy and trade and economic growth are linked in both directions in all explored countries. Another study focused on how renewable energy consumption, ecological footprint and economic growth in the US. In the ARDL model, it is possible to link a rise in renewable energy consumption with the reduction of environmental deterioration (Usman et al., 2020). Using different statistical techniques, Armeanu et al. (2021) examine the connections between renewable energy, distinct forms of energy, economic growth, carbon intensity, and rapid urbanisation in

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various nations with varying income levels and discovered that in developed countries, there exists the co-integration among renewable energy consumption and carbon releases from renewable and nuclear sources. As per the Granger causality test, there is only one bidirectional causal connection between economic growth and resource consumption in developing countries, whereas there are numerous bidirectional connections between energy intensity and carbon emissions in developed countries.

Researchers such as Hao et al. (2021) employ panel data techniques, to examine the consequences of green growth in G7 countries during the past 25 years. According to the conclusions of this study, environmental deterioration is affected by both short-term and long-term GDP development. As a result, the claim that green growth improves the environment is valid. Changing CO_2, GDP, green economy, environmental regulation, renewable power consumption, or human resources in all of the seven G7 countries will have an impact on the others.

Conversely, energy usage has a beneficial impact on growth in several low- and middle-income nations, whereas renewable energy sources have a negative impact (Namahoro et al., 2021a). Panel data methodologies are used by Li and Leung (2021) instead of acceptable and realistic econometrics modelling techniques to explore the connection between economic growth, energy prices, and renewable energy use. The new study by Li and Leung (2021) shows that even in countries like the G7 whose economies are well-established, increasing renewable energy requires economic growth. In another study, the use of renewable energy has been shown to have a positive impact on economic growth (Namahoro et al., 2021b). Renewable energy use in the G7 countries has a beneficial impact on economic growth. This positive association is affected by the threshold value. As a result, renewable energy's function in promoting economic growth is non-linear. For example, renewable energy's role in fostering economic growth will be amplified if EU members raise their use of it above a certain threshold. Concerning renewable energy consumption and economic growth, Chen et al. (2020) used a threshold model in their study published in 2020. These studies, which use the years 1995–2015 as a baseline, show that renewable energies have a large and favourable impact on economic growth in OECD nations, but not in developed ones. When renewable energy consumption reaches a particular level in emerging and non-OECD nations, it greatly impacts economic growth. According to Sharma et al. (2021), switching to renewable energy has more long-term economic benefits than short-term costs using dynamic panel data estimation.

4. Renewable Energy and Economic Growth in Developing Countries

There is a lack of reliable, affordable, and long-lasting electrical power in rural areas of impoverished and developing countries. As a result of a lack of renewable energy options, residents in both urban and rural areas in these countries must rely on fossil fuels. Bangladesh's energy industry is still in its infancy, hindering the country from progressing economically. Sustainable development goals (SDG) can only be achieved if the proportion of renewable energy in the power mix is increased and resource usage for energy production is reduced and reduced (Baniya et al., 2021). These include short-term power stations, coal-fired plant operations, and imports from surrounding nations to reduce the imbalance in supply and demand. There is still a long way to go before the country can produce and supply enough electricity. In addition, the country's considerable use of renewable energy is hampered by growing FDI inflows linked to the energy sector. The increased usage of renewable energy in the region, particularly in Bangladesh, is also being spurred by the region's growing economy and rising CO_2 emissions (Murshed 2021; Bhuiyan et al., 2021). The addition of tidal power, another renewable energy source, to the nation's electrical grid could be crucial (Ahmad and Hasan, 2021). Alam et al. (2017) suggest that Bangladesh must adopt renewable energy and demand-side treatment to reduce a detrimental influence on the country's economy since economic development translates to higher energy usage. One of Africa's greatest exporters of fossil fuels is Nigeria, one of the developing nations. This country, on the other hand, has recently been confronted

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with a major energy crisis. In recent years, biofuel (bioethanol and biodiesel) has been recognised as renewable energy. This abundant supply of waste and feedstocks could catalyze Nigeria's economic growth in the future (Adewuyi, 2020). The economic impact of renewable and non-renewable energy systems is discussed in Islam et al. (2022). The use of renewable and non-renewable energy is positively influenced by domestic investment. The usage of renewable energy sources has been shown to benefit from FDI. Non-renewable energy consumption benefits from urbanisation, but renewable energy consumption suffers as a result of urbanisation. There are both good and negative impacts on the use of renewable and non-renewable energy from the physical infrastructure.

According to Ramadan (2017), the government subsidies for installing the new renewable energy plants or reducing the financing rates enhance the economic benefits. Ghouchani et al. (2021) look into the possibility of developing renewable energy in Iran. Long-run technology acquisition plans, regulatory stabilisation, and "attraction of foreign investment" are all addressed in this research as potential opportunities for Iran's energy industry. Policies that are most flexible to national goals, technological capacity, and economies might be selected for consideration while formulating and implementing a renewable energy policy.

Wang and Wang (2020) looked studied the impact of consolidated and disaggregated alternative renewable energy usage on Pakistan's GDP per capita. They conclude that economic growth is boosted by using fossil fuels, however, this is not useful in the later phases of the industrial process. When expanding production in Pakistan, the use of clean energy is not advantageous in the early phases of production, but it is beneficial later on in the process for the environment as well. Research shows that Pakistan's human development does not improve when it uses renewable energy. Unexpectedly, the higher a country's income rises in direct proportion to its educational attainment. The human development index is also boosted by CO_2 emissions. In addition, Pakistan's human development is stifled by trade liberalisation. Using causality analysis, the long-term feedback concept between environmental impacts and human development is backed up again.

Doytch and Narayan (2021) assert that the growth of the economy is boosted by the use of renewable energy. In South Korea, investment in the production of renewable power has both economic and environmental benefits, according to Sim (2018) and Shan et al. (2021) considering the effect of green sector development and renewable energy in Turkey's drive for emissions reduction. Renewable energy, energy use, population growth, and per income per capita are all interconnected in the long run. Green technology innovations and carbon emissions are being cut yet at the same time global energy use, population growth and per capita carbon emissions are all rising. For a contemporary period of growing development in Vietnam, Nong et al. (2020) examine the country's energy policy. It has been shown that renewable energy can offset the negative effects of environmental challenges on social and economic well-being.

5. Conclusion

It is no longer a country-specific concern to deal with global warming, environmental pollution, and other associated challenges. As a means to promote the concept of sustainable development, the clean development mechanism entails a vast deployment of renewable energy technologies. Energy security is quickly becoming a reality as various renewable energy supplies are exploited, in addition to their potential for mitigating GHG emissions. As part of the UNFCCC, the Kyoto Protocol incorporates the idea of a "clean development framework". It is expected that developed nations would contribute to emission reduction measures, which would then be used to fund renewable energy programmes in the developing world. Increasing the usage of green technology and renewable energy sources can help address this problem. However, mass sustainable energy development faces just a few obstacles, including unpredictability, input-output cost analysis, a higher manufacturing cost, and a lack of knowledge and financial resources. Researchers have discovered, based on their previous studies, that renewable energy sources are critical to

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the country's overall growth. Developing countries must increase their reliance on renewable energy sources.

Reduced emissions can be attributed to the use of renewable energy and other natural resources. As a result, global monitoring of the impact of CO_2 emissions on the environment is required to assess the effects of climate change. All of these effects are weighted according to the economic situation in each country. The industrial structure is being transformed by green growth and eco-innovation, according to Hao et al. (2021). To meet the Sustainable development goals, developed countries must prioritise a green growth strategy.

The use of renewable energy systems in a country's economic growth is critical in developing countries with high renewable energy capacity. Fossil fuels may be helpful in the early phases of manufacturing, but they aren't in the latter stages of production, according to our findings. However, while employing clean energy may not be beneficial at the outset of expanding manufacturing activities in developing countries, its benefits extend far beyond the production stage. To lessen the effects of climate change, policymakers should move quickly to implement comprehensive reforms in the area of renewable energy. Globalization has been shown to encourage Latin American countries' use of renewable energy sources (Koengkan et al., 2020). The development of green energy technology will benefit the region and the world as a whole a result of this. Policymakers should take advantage of globalisation to lower the costs of renewable energy technology as well as implement regulations that encourage the usage of these technologies by low-income households.

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Abbreviation	Full name
ARDL Model	An autoregressive distributed lag (ARDL) Model
CCEMG approach	A common correlated effect means group Model.
CS-ARDL approach	Cross-sectionally augmented autoregressive distributed lag (CS-ARDL) modelling approach
CSDL approach	The cross-sectional augmented Autoregressive distributed lagged.
CO_2 emissions	Carbon dioxide emissions
DEA approach	Data envelopment analysis approach.
EU countries	European Union countries
FDI	Foreign direct investment
FOLS Model	Fixed effect ordinary least square Model.
GMM-PVAR Model	Panel vector autoregression technique.
G7	World's seven largest developed economies.
NARDL Model	A Nonlinear Autoregressive Distributed Lag Model.
OECD countries	The Organization for Economic Co-operation and Development countries.
RESD	Renewable energy and sustainable development.
SDG	Sustainable development goals.
STIRPAT Model	Stochastic Impacts by Regression on Population, Affluence and Technology Model.
UNFCCC	The United Nations Framework Convention on Climate Change.

References

Acheampong, A. O., Dzator, J., & Savage, D. A. (2021). Renewable energy, CO_2 emissions and economic growth in sub-Saharan Africa: Does institutional quality matter?. *Journal of Policy Modeling*, *43*(5), 1070-1093. https://doi.org/10.1016/j.jpolmod.2021.03.011

Adewuyi, A. (2020). Challenges and prospects of renewable energy in Nigeria: A case of bioethanol and biodiesel production. *Energy Reports*, *6*, 77-88. https://doi.org/10.1016/j.egyr.2019.12.002

Ahmad, M., & Hasan, G. J. (2021). Renewable energy in Bangladesh: status and potential. In *Design, Analysis, and Applications of Renewable Energy Systems* (pp. 607-625). Academic Press. https://doi.org/10.1016/B978-0-12-824555-2.00023-X

Ahmad, M., Jiang, P., Murshed, M., Shehzad, K., Akram, R., Cui, L., & Khan, Z. (2021). Modelling the dynamic linkages between eco-innovation, urbanization, economic growth and ecological footprints for G7 countries: does financial globalization matter?. *Sustainable Cities and Society*, *70*, 102881. https://doi.org/10.1016/j.scs.2021.102881

Alam, M. J., Ahmed, M., & Begum, I. A. (2017). Nexus between non-renewable energy demand and economic growth in Bangladesh: Application of Maximum Entropy Bootstrap approach. *Renewable and Sustainable Energy Reviews*, *72*, 399-406. https://doi.org/10.1016/j.rser.2017.01.007

Al-Mulali, U. (2014). Investigating the impact of nuclear energy consumption on GDP growth and CO_2 emission: A panel data analysis. *Progress in Nuclear Energy*, *73*, 172–178. https://doi.org/10.1016/j.pnucene.2014.02.002

Alper, A., & Oguz, O. (2016). The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renewable and Sustainable Energy Reviews*, *60*, 953-959. https://doi.org/10.1016/j.rser.2016.01.123

Amri, F. (2017). Intercourse across economic growth, trade and renewable energy consumption in developing and developed countries. *Renewable and Sustainable Energy Reviews*, *69*, 527-534. https://doi.org/10.1016/j.rser.2016.11.230

Apergis, N., & Payne, J. E. (2011). The renewable energy consumption–growth nexus in Central America. *Applied Energy*, *88*(1), 343-347. https://doi.org/10.1016/j.apenergy.2010.07.013

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. https://doi.org/10.1016/j.eneco.2011.04.007

Armeanu, D. S., Joldes, C. C., Gherghina, S. C., & Andrei, J. V. (2021). Understanding the multidimensional linkages among renewable energy, pollution, economic growth and urbanization in contemporary economies: Quantitative assessments across different income countries' groups. *Renewable and Sustainable Energy Reviews*, *142*, 110818. https://doi.org/10.1016/j.rser.2021.110818

Aslan, A., Ocal, O., Ozsolak, B., & Ozturk, I. (2022). Renewable energy and economic growth relationship under the oil reserve ownership: Evidence from panel VAR approach. *Renewable Energy*, 188, 402-410. https://doi.org/10.1016/j.renene.2022.02.039.

Baniya, B., Giurco, D., & Kelly, S. (2021). Green growth in Nepal and Bangladesh: Empirical analysis and prospects. *Energy Policy*, *149*, 112049. https://doi.org/10.1016/j.enpol.2020.112049

Bhattacharya, M., Paramati, S. R., Ozturk, I., & Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy*, *162*, 733–741. https://doi.org/10.1016/j.apenergy.2015.10.104

Bhuiyan, M. R. A., Mamur, H., & Begum, J. (2021). A brief review on renewable and sustainable energy resources in Bangladesh. *Cleaner Engineering and Technology*, *4*, 100208. https://doi.org/10.1016/j.clet.2021.100208

Chen, Y., Mamon, R., Spagnolo, F., & Spagnolo, N. (2022). Renewable energy and economic growth: A Markov-switching approach. *Energy*, 244, 123089. https://doi.org/10.1016/j.energy.2021.123089.

Chen, C., Pinar, M., & Stengos, T. (2020). Renewable energy consumption and economic growth nexus: Evidence from a threshold model. *Energy Policy*, *139*, 111295. https://doi.org/10.1016/j.enpol.2020.111295

Doytch, N., & Narayan, S. (2021). Does transitioning towards renewable energy accelerate economic growth? An analysis of sectoral growth for a dynamic panel of countries. *Energy*, *235*, 121290. https://doi.org/10.1016/j.energy.2021.121290

Eyuboglu, K., & Uzar, U. (2022). Asymmetric causality between renewable energy consumption and economic growth: fresh evidence from some emerging countries. *Environmental Science and Pollution Research*, 29(15), 21899-21911. https://doi.org/10.1007/s11356-021-17472-9.

Ghouchani, M., Taji, M., Cheheltani, A. S., & Chehr, M. S. (2021). Developing a perspective on the use of renewable energy in Iran. *Technological Forecasting and Social Change*, *172*, 121049. https://doi.org/10.1016/j.techfore.2021.121049

Gyimah, J., Yao, X., Tachega, M. A., Hayford, I. S., & Opoku-Mensah, E. (2022). Renewable energy consumption and economic growth: New evidence from Ghana. *Energy*, 248, 123559. https://doi.org/10.1016/j.energy.2022.123559.

Hao, L. N., Umar, M., Khan, Z., & Ali, W. (2021). Green growth and low carbon emission in G7 countries: how critical the network of environmental taxes, renewable energy and human capital is?. *Science of The Total Environment*, *752*, 141853. https://doi.org/10.1016/j.scitotenv.2020.141853

İnal, V., Addi, H. M., Çakmak, E. E., Torusdağ, M., & Çalışkan, M. (2022). The nexus between renewable energy, CO2 emissions, and economic growth: empirical evidence from African oil-producing countries. *Energy Reports*, 8, 1634-1643. https://doi.org/10.1016/j.egyr.2021.12.051.

Inglesi-Lotz, R. (2016). The impact of renewable energy consumption to economic growth: A panel data application. *Energy Economics*, *53*, 58-63. https://doi.org/10.1016/j.eneco.2015.01.003

Irfan, M., Zhao, Z. Y., Rehman, A., Ozturk, I., & Li, H. (2021). Consumers' intention-based influence factors of renewable energy adoption in Pakistan: a structural equation modeling approach. *Environmental Science and Pollution Research*, *28*(1), 432-445. https://doi.org/10.1007/s11356-020-10504-w

Islam, M. M., Irfan, M., Shahbaz, M., & Vo, X. V. (2022). Renewable and non-renewable energy consumption in Bangladesh: the relative influencing profiles of economic factors, urbanization, physical infrastructure and institutional quality. *Renewable Energy*, *184*, 1130-1149. https://doi.org/10.1016/j.renene.2021.12.020

Ivanovski, K., Hailemariam, A., & Smyth, R. (2021). The effect of renewable and non-renewable energy consumption on economic growth: Non-parametric evidence. *Journal of Cleaner Production*, *286*, 124956. https://doi.org/10.1016/j.jclepro.2020.124956

Jenniches, S. (2018). Assessing the regional economic impacts of renewable energy sources–A literature review. *Renewable and Sustainable Energy Reviews*, *93*, 35-51. https://doi.org/10.1016/j.rser.2018.05.008

Kahia, M., Aïssa, M. S. B., & Lanouar, C. (2017). Renewable and non-renewable energy use-economic growth nexus: The case of MENA Net Oil Importing Countries. *Renewable and Sustainable Energy Reviews*, *71*, 127-140. https://doi.org/10.1016/j.rser.2017.01.010

Kuo, Y., Maneengam, A., The, C. P., An, N. B., Nassani, A. A., Haffar, M., & Qadus, A. (2022). Fresh evidence on environmental quality measures using natural resources, *Renewable Energy*, non-renewable energy and economic growth for 10 Asian nations from CS-ARDL technique. *Fuel*, 320, 123914. https://doi.org/10.1016/j.fuel.2022.123914.

Koengkan, M., Fuinhas, J. A., & Santiago, R. (2020). The relationship between CO_2 emissions, renewable and non-renewable energy consumption, economic growth, and urbanisation in the Southern Common Market. *Journal of Environmental Economics and Policy*, *9*(4), 383-401. https://doi.org/10.1080/21606544.2019.1702902

Konuk, F., Zeren, F., Akpınar, S., & Yıldız, Ş. (2021). Biomass energy consumption and economic growth: Further evidence from NEXT-11 countries. *Energy Reports*, *7*, 4825-4832. https://doi.org/10.1016/j.egyr.2021.07.070.

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

Larcher, D., & Tarascon, J. M. (2015). Towards greener and more sustainable batteries for electrical energy storage. *Nature Chemistry*, *7*(1), 19-29. https://doi.org/10.1038/nchem.2085

Lema, R., Bhamidipati, P. L., Gregersen, C., Hansen, U. E., & Kirchherr, J. (2021). China's investments in renewable energy in Africa: Creating co-benefits or just cashing-in?. *World Development*, *141*, 105365. https://doi.org/10.1016/j.worlddev.2020.105365

Li, R., & Leung, G. C. (2021). The relationship between energy prices, economic growth and renewable energy consumption: Evidence from Europe. *Energy Reports*, *7*, 1712-1719. https://doi.org/10.1016/j.egyr.2021.03.030

Menegaki, A. N. (2011). Growth and renewable energy in Europe: A random effect model with evidence for neutrality hypothesis. *Energy Economics*, *33*(2), 257-263. https://doi.org/10.1016/j.eneco.2010.10.004

Menyah, K., & Wolde-Rufael, Y. (2010). CO_2 emissions, nuclear energy, renewable energy and economic growth in the US. *Energy Policy*, *38*(6), 2911-2915. https://doi.org/10.1016/j.enpol.2010.01.024.

Mohsin, M., Taghizadeh-Hesary, F., Iqbal, N., & Saydaliev, H. B. (2022). The role of technological progress and renewable energy deployment in green economic growth. *Renewable Energy*, 190, 777-787. https://doi.org/10.1016/j.renene.2022.03.076.

Mukhtarov, S. (2022). The relationship between renewable energy consumption and economic growth in Azerbaijan. *International Journal of Energy Economics and Policy*, 12(1), 416-419. https://doi.org/10.32479/ijeep.11948.

Murshed, M., Rashid, S., Ulucak, R., Dagar, V., Rehman, A., Alvarado, R., & Nathaniel, S. P. (2022). Mitigating energy production-based carbon dioxide emissions in Argentina: the roles of renewable energy and economic globalization. *Environmental Science and Pollution Research*, 29(12), 16939-16958. https://doi.org/10.1007/s11356-021-16867-y.

Murshed, M. (2021). Can regional trade integration facilitate renewable energy transition to ensure energy sustainability in South Asia?. *Energy Reports*, *7*, 808-821. https://doi.org/10.1016/j.egyr.2021.01.038

Namahoro, J. P., Nzabanita, J., & Wu, Q. (2021a). The impact of total and renewable energy consumption on economic growth in lower and middle-and upper-middle-income groups: Evidence from CS-DL and CCEMG analysis. *Energy*, *237*, 121536. https://doi.org/10.1016/j.energy.2021.121536

Namahoro, J. P., Wu, Q., Xiao, H., & Zhou, N. (2021b). The asymmetric nexus of renewable energy consumption and economic growth: New evidence from Rwanda. *Renewable Energy*, *174*, 336-346. https://doi.org/10.1016/j.renene.2021.04.017

Nathaniel, S., & Khan, S. A. R. (2020). The nexus between urbanization, renewable energy, trade, and ecological footprint in ASEAN countries. *Journal of Cleaner Production*, *272*, 122709. https://doi.org/10.1016/j.jclepro.2020.122709

Nong, D., Wang, C., & Al-Amin, A. Q. (2020). A critical review of energy resources, policies and scientific studies towards a cleaner and more sustainable economy in Vietnam. *Renewable and Sustainable Energy Reviews*, *134*, 110117. https://doi.org/10.1016/j.rser.2020.110117

Ocal, O., & Aslan, A. (2013). Renewable energy consumption–economic growth nexus in Turkey. *Renewable and Sustainable Energy Reviews*, *28*, 494-499. https://doi.org/10.1016/j.rser.2013.08.036

Ogonowski, P. (2021). Application of VMCM, to assess of renewable energy impact in European Union Countries. *Procedia Computer Science*, *192*, 4762-4769. https://doi.org/10.1016/j.procs.2021.09.254

Oluoch, S., Lal, P., Susaeta, A., & Vedwan, N. (2020). Assessment of public awareness, acceptance and attitudes towards renewable energy in Kenya. *Scientific African*, *9*, e00512. https://doi.org/10.1016/j.sciaf.2020.e00512

Omri, A. (2020). Technological innovation and sustainable development: does the stage of development matter?. *Environmental Impact Assessment Review*, *83*, 106398. https://doi.org/10.1016/j.eiar.2020.106398

Ozturk, I., & Bilgili, F. (2015). Economic growth and biomass consumption nexus: Dynamic panel analysis for Sub-Sahara African countries. *Applied Energy*, *137*, 110-116. https://doi.org/10.1016/j.apenergy.2014.10.017

Pao, H. T., & Fu, H. C. (2013). Renewable energy, non-renewable energy and economic growth in Brazil. *Renewable and Sustainable Energy Reviews*, *25*, 381-392. https://doi.org/10.1016/j.rser.2013.05.004

Park, S. H., Jung, W. J., Kim, T. H., & Lee, S. Y. T. (2016). Can renewable energy replace nuclear power in Korea? An economic valuation analysis. *Nuclear Engineering and Technology*, *48*(2), 559-571. https://doi.org/10.1016/j.net.2015.12.012.

Østergaard, P. A., Duic, N., Noorollahi, Y., Mikulcic, H., & Kalogirou, S. (2020). Sustainable development using renewable energy technology. *Renewable Energy*, 146, 243-437. https://doi.org/10.1016/j.renene.2019.08.094.

Østergaard, P. A., & Sperling, K. (2014). Towards sustainable energy planning and management. *International Journal of Sustainable Energy Planning and Management*, 1, 1-6. https://doi.org/10.5278/ijsepm.2014.1.

Rahman, M. M., & Velayutham, E. (2020). Renewable and non-renewable energy consumption-economic growth nexus: New evidence from South Asia. *Renewable Energy*, *147*, 399–408. https://doi.org/10.1016/j.renene.2019.09.007

Ram, M., Child, M., Aghahosseini, A., Bogdanov, D., Lohrmann, A., & Breyer, C. (2018). A comparative analysis of electricity generation costs from renewable, fossil fuel and nuclear sources in G20 countries for the period 2015-2030. *Journal of Cleaner Production*, *199*, 687–704. https://doi.org/10.1016/j.jclepro.2018.07.159

Ramadan, H. S. (2017). Wind energy farm sizing and resource assessment for optimal energy yield in Sinai Peninsula, Egypt. *Journal of Cleaner Production*, *161*, 1283-1293. https://doi.org/10.1016/j.jclepro.2017.01.120

Sadorsky, P. (2009). Renewable energy consumption and income in emerging economies. *Energy Policy*, *37*(10), 4021-4028. https://doi.org/10.1016/j.enpol.2009.05.003

Seetharaman, A., Moorthy, K., Patwa, N., & Saravanan, G. Y. (2019). Breaking Barriers in Deployment of Renewable Energy,"Heliyon" 5 (1), e01166. https://doi.org/10.1016/j.heliyon.2019.e01166

Shan, S., Genç, S. Y., Kamran, H. W., & Dinca, G. (2021). Role of green technology innovation and renewable energy in carbon neutrality: A sustainable investigation from Turkey. *Journal of Environmental Management*, *294*, 113004. https://doi.org/10.1016/j.jenvman.2021.113004

Sharma, G. D., Tiwari, A. K., Erkut, B., & Mundi, H. S. (2021). Exploring the nexus between non-renewable and renewable energy consumptions and economic development: Evidence from panel estimations. *Renewable and Sustainable Energy Reviews*, *146*, 111152. https://doi.org/10.1016/j.rser.2021.111152

Shrinkhal, R. (2019). Economics, technology, and environmental protection: a critical analysis of phytomanagement. In *Phytomanagement of Polluted Sites* (pp. 569-580). Elsevier. https://doi.org/10.1016/B978-0-12-813912-7.00022-3

Sim, J. (2018). The economic and environmental values of the R&D investment in a renewable energy sector in South Korea. *Journal of Cleaner Production*, *189*, 297-306. https://doi.org/10.1016/j.jclepro.2018.04.074

Slusarczyk, B., Żegleń, P., Kluczek, A., Nizioł, A., & Górka, M. (2022). The Impact of Renewable Energy Sources on the Economic Growth of Poland and Sweden Considering COVID-19 Times. *Energies*, 15(1), 332. https://doi.org/10.3390/en15010332.

Soytas, U., & Sari, R. (2003). Energy consumption and GDP: causality relationship in G-7 countries and emerging markets. *Energy Economics*, *25*(1), 33-37. https://doi.org/10.1016/S0140-9883(02)00009-9

Steve, Y. S., Murad, A. B., Gyamfi, B. A., Bekun, F. V., & Uzuner, G. (2022). Renewable energy consumption a panacea for sustainable economic growth: panel causality analysis for African blocs. *International Journal of Green Energy*, 19(8), 847-856. https://doi.org/10.1080/15435075.2021.1966793.

Usman, O., Alola, A. A., & Sarkodie, S. A. (2020). Assessment of the role of renewable energy consumption and trade policy on environmental degradation using innovation accounting: Evidence from the US. *Renewable Energy*, *150*, 266-277. https://doi.org/10.1016/j.renene.2019.12.151

Vaona, A. (2012). Granger non-causality tests between (non) renewable energy consumption and output in Italy since 1861: The (ir) relevance of structural breaks. *Energy Policy*, *45*, 226-236. https://doi.org/10.1016/j.enpol.2012.02.023.

Wang, Q., Dong, Z., Li, R., & Wang, L. (2022). Renewable energy and economic growth: new insight from country risks. *Energy*, 238, 122018. https://doi.org/10.1016/j.energy.2021.122018.

Wang, Q., & Wang, L. (2020). Renewable energy consumption and economic growth in OECD countries: A nonlinear panel data analysis. *Energy*, *207*, 118200. https://doi.org/10.1016/j.energy.2020.118200

Wang, Q., Wang, L., & Li, R. (2022). Renewable energy and economic growth revisited: The dual roles of resource dependence and anticorruption regulation. *Journal of Cleaner Production*, 337, 130514. https://doi.org/10.1016/j.jclepro.2022.130514.

Yildirim, E., Saraç, Ş., & Aslan, A. (2012). Energy consumption and economic growth in the USA: Evidence from renewable energy. *Renewable and Sustainable Energy Reviews*, *16*(9), 6770-6774. https://doi.org/10.1016/j.rser.2012.09.004

Zebra, E. I. C., van der Windt, H. J., Nhumaio, G., & Faaij, A. P. (2021). A review of hybrid renewable energy systems in mini-grids for off-grid electrification in developing countries. *Renewable and Sustainable Energy Reviews*, *144*, 111036. https://doi.org/10.1016/j.rser.2021.111036

Zhao, X., Mahendru, M., Ma, X., Rao, A., & Shang, Y. (2022). Impacts of environmental regulations on green economic growth in China: New guidelines regarding renewable energy and energy efficiency. *Renewable Energy*, 187, 728-742. https://doi.org/10.1016/j.renene.2022.01.076.