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| RESEARCH ARTICLE

The Causal Relationship of Renewable Energy and Non-renewable Energy Consumption to the Economic Growth of the Philippines

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| ABSTRACT
The Philippines has one of the highest electricity prices in Asia. Contributing factors to these are the short supply of domestic coal and oil resources, the high cost of imported coal, and the lack of pursuit of renewable energy. This paper looks into the causal relationship between energy consumption and economic growth in the Philippines. It identified if a Granger causality exists between variables GDP per capita, renewable energy consumption per capita and nonrenewable energy consumption per capita. An objective was to identify if shifting to renewable energy is a means to further spur Philippine economic growth. GDP per capita data was taken from the World Bank, while energy consumption per capita of renewable and nonrenewable energy was calculated from Our World in Data ranging from years 1965 to 2019. Granger causality tests were used to determine if said variables Granger caused one another. Results show support to the null hypothesis that renewable energy consumption and nonrenewable energy consumption per capita do not Granger cause GDP per capita. A significant positive relationship was found between nonrenewable energy consumption and GDP. Taken together, these empirical findings provide valuable information for policymakers and future researchers. Results suggest that energy conservation policies may still be implemented in the Philippines without negatively affecting economic growth. Policy recommendations include the usage of renewable energy sources to mitigate environmental degradation and reduce carbon emissions. As renewable energy becomes more appealing as a source of efficient and sustainable electricity, significant support and attention must continually be given to the country's renewable energy industry.

| KEYWORDS

Economic growth, renewable energy consumption, nonrenewable energy consumption, Causal Relationship, Philippines.

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1. Introduction

World economies became heavily dependent on electricity, which resulted in both industrialization and digitalization. According to Wolde-Rufael (2003), electricity (energy in general) is an important promoter of socioeconomic development. Asghar (2008) also states that energy is a significant source of economic growth since many production and consumption activities require energy as a basic input, one of the most important economic growth inputs. With this being said, the electric power sector is one of the most important for pass-through energy in modern economies (Ebenhack et al., 2018). As this is a pass-through sector that provides energy to all end-use sectors, the efficiency of electric power production is critical to the overall efficiency of any system. In today's society, the level of energy demand is crucially significant. It is a key element in a country's physical and social development and its economic growth (Hasan et al., 2012). Benders et al. (2008) stated that while there is more research in developed countries than the developing ones, it is due to the fact that energy was probably more significant as a driver of economic development in today's developing economies when they were at a lower income level. Moreover, according to Ahuja and Tatsutani (2009), increasing prosperity and economic opportunity trends in most of the world have been closely linked to steady growth in energy consumption. However, mankind is now dealing with an enormous energy challenge.

The Philippines is one of the developing countries with access to electricity. However, the increased access to electricity showed that the country is still grappling with energy insecurity issues (Ahuja and Tatsutani, 2009). In comparison to neighbouring countries, the Philippines' domestic coal and oil resources are said to be in short supply. End-users of electricity also pay increased rates as a result of the high cost of imported coal (Koebrich & Speer, 2019). Despite reform efforts, power rates in the Philippines continue to be among the highest in Asia and remain a source of concern for industries in the country struggling to remain competitive with their regional counterparts (Bautista & Valderrama, 2012). According to Dulce et al. (2011), the government's policy reforms in the energy sector is just the beginning of a series of challenges in energy governance as the country engages with global energy markets while still dealing with domestic issues. The challenges tend to revolve around the following themes: alignment of global energy markets to ensure energy security, policy reforms and the expectation of lower energy prices, and the emergence of the climate change imperative.

The Philippines still uses predominantly nonrenewable energy, particularly coal, as its main source of electricity. The paper looks at renewable energy (RE) as a viable source of sustainable energy that can improve efficiency in the Philippines' electricity consumption. According to Abe & Hong (2012), renewable energy systems (RESs) such as solar, wind, hydro, biomass, and geothermal have been promoted for rural electrification as a solution to communities' growing energy demands while also addressing environmental and resource scarcity issues. While Brahim (2014) conducted a study regarding the importance of renewable energy to the energy security and sustainability of the Philippines. The result showed that renewable energy would become a larger part of the Philippine energy mix for power generation in the not-too-distant future. However, despite the fact that renewable energy is progressively increasing its contribution to global final energy consumption, fossil fuels, especially oil, will continue to be the dominant energy source (Brahim, 2014).

The aim of this paper is to first determine if there is a causal relationship between renewable and nonrenewable energy consumption and GDP per capita, respectively. As it is supported that electricity is a driver of economic growth, the study would like to identify whether it is renewable or nonrenewable energy with a Granger causality with Philippine economic growth. Examination of the impact of renewable energy on the Philippine economy will follow since this can be a more efficient alternative energy source that also has less detrimental effects on the environment. Furthermore, the electrical industry's issues and policies will be discussed, focusing on renewable and nonrenewable energy consumption.

2. Overview of the Philippine Electricity Industry

The restructured electric power industry in the Philippines is composed of four sectors: generation, transmission, distribution, and supply. Generators convert primary energy sources (such as oil, coal and hydro) as well as renewable sources (such as solar, wind, and ocean) into electricity. Transmission utilities transport electricity produced by generators through high-voltage wires. Distribution utilities transform high-voltage electricity to lower voltage wires with the goal of supplying individual customers; thus, the major product produced by the industry is electric power, and its complementary services consist of transmission services, distribution services, and suppliers' services that involve selling, brokering, marketing or aggregating electricity to the end-users (Patalinghug, 2013).

The electricity sector is one of the necessary utilities in any country (Chirwa & Odhiambo, 2020). Electricity has remained an important input for all production processes and a need for all households until now. Electricity use could result in not only a better quality of life but can also aggravate impacts on the environment due to inappropriate use (Chen et al., 2007). ASEAN co-member Indonesia's electricity demand has grown strongly as it has in other energy sectors. Gas turbines, steam turbines, combined cycles, geothermal, diesel engines, and hydropower are the major sources of electrical energy. However, the majority of Indonesia's power plants still generate electricity using fossil fuels (Hasan et al., 2012). Similarly, the Philippines has been experiencing rapidly growing electricity demand, which is expected to be met mainly with coal. The development of coal-fired electricity generation is the result of a complex interaction of political and economic factors (Jakob & Manych, 2021). This indicates that the Philippines is not the only country that is reliant on nonrenewable energy, but so are its neighbouring countries.

According to Cuartero and Enteria (2017), the Philippines has become one of the largest and most dynamic economies in Southeast Asia in recent years as a result of several national reforms implemented by the government. This expanding economy now requires higher energy consumption. According to Jamasb et al. (2015), reforms in the electricity sector have been said to improve efficiency and productivity among many reforming countries. However, due to the inability of sector regulators and inadequate regulatory frameworks, efficiency gains have not always reached end consumers. Only when the poor have access to electricity, do reforms reduce poverty and promote the welfare of the poor. From a policy-making perspective, this means that the changes must be coupled with additional measures to speed up electrification to benefit the disadvantaged (Jamasb et al., 2015). This is a significant finding for the Philippines as it is a developing country, and poverty alleviation is also a crucial issue that must be addressed.

2.1 Renewable Energy

One major avenue for policymakers to attain climate targets is by decarbonizing the power sector, which includes increasing the share of renewable energy sources in electricity generation (Blazquez et al., 2018). The findings of Shahbaz et al. (2018) propose government policies focused on promoting renewable energy markets in order to improve energy efficiency in the United States.

In a study conducted by Bertheau and Cader (2019), they compared the feasibility of submarine cable interconnection and renewable energy-based hybrid system development for 132 islands. The results showed that renewable energy-based hybrid systems are the most viable option for most islands. While Ali et al. (2017) analyzed the factors that affect African households' use of renewable and clean energy sources for lighting. Econometric findings indicate that female-headed households are more likely to use clean and renewable energy sources relative to male-headed households. Electricity and solar energy are used by wealthier and more skilled households for lighting, while kerosene, batteries, and solid fuels are used by poorer households.

Meanwhile, Krozer (2013), who made a cost-benefit analysis of renewable energy in the European Union, discovered a net profit of 47 billion euros due to the growing usage of renewable energy during the oil price cycle. On average, this amounts to 8 billion euros per year. This claimed net profit is also said to exceed the European Union's overall public funding for renewable energy. Furthermore, correlations show that higher renewable energy usage has a major effect on shifts in consumer electricity prices during periods of high and rapidly rising fossil fuel prices. The increased use has resulted in lower prices in most countries that use more renewable energy and higher prices in many countries that use less renewable energy. Additionally, renewable energy generation has also been found to decrease the price volatility of electricity prices stated in Rintamaki et al.'s study in 2017.

Moreover, renewable energy consumption positively impacts unemployment, especially in Asia and Latin America (Apergis & Salim, 2015). However, disaggregated data led to the conclusion that the impact of renewable energy use on job creation is influenced by the cost of implementing renewable energy technologies and energy efficiencies, which seem to differ across the regions studied.

2.1.2 Geothermal

The energy stored as heat in the Earth's interior is known as geothermal energy (Barbier, 2002). For decades, geothermal energy has been used to create power and space heating and industrial operations in the form of natural steam and hot water. Geothermal energy is classified as a renewable energy source, which indicates that its availability is unaffected by a shortage of supply or rising fossil oil prices. One of the benefits of geothermal energy is that it is environmentally friendly (Aditya et al., 2016).

Electricity generation and direct use are both possible with geothermal energy. When compared to other energy sources, it emits fewer greenhouse gases, making it a more environmentally friendly option. According to Komurcu & Akpinar (2009) study, in Turkey, which has abundant geothermal resources, the geothermal heating potential in Turkey alone could heat 5 million homes. As a result, 48 million tons of CO_2 will be prevented from entering the atmosphere each year. This asserts that taking advantage of geothermal potential will have significant environmental benefits.

2.1.3 Hydro

Hydropower is currently the world's greatest renewable energy source, and it plays a significant part in worldwide power generation (Aroonrat & Wongwises, 2015). According to Bakhtyar et al. (2013), Indonesia and the Philippines have a tropical climate and high amounts of rain; thus, they have a lot of potential for hydropower and wind energy deployment. The countries' volcanic geography indicates how they have a high geothermal potential compared to other countries. Their high solar radiation level makes them suitable areas for establishing power plants.

In various countries, hydropower is the most frequently used renewable energy source. According to Pata & Aydin (2020), there was unidirectional causation between hydropower energy consumption and economic growth in Brazil, while there was bidirectional causation between these variables in China.

2.1.4 Biomass

According to Juchelkova et al. (2019), most Southeast Asian countries have an abundance of biomass sources for the energy industry due to their agriculture-based economies and vast forest resources. It was found in their study that the major biomass sources in this region include fuelwood, wood residues, rice husk, rice straw, sugarcane residues, oil palm scraps, and coconut residues. The Southeast Asian region's total annual biomass potential from agriculture and the forest sector was projected to generate higher than 500 million tons per year, equivalent to greater than 8000 million gigajoules of total energy potential.

In a study by Alam et al. (2018), results show that most households in Bangladesh rely significantly on biomass energy, which accounts for 87 percent of their monthly energy use and two-thirds of their energy expenditure. Meanwhile, in the Philippines, bioenergy sources have been under significant strain due to its country's growing population, increased deforestation, and rising fossil fuel prices. Wood fuel accounts for the largest share of biomass power generation in the country. According to De Maio et al. (2001), crop residues as biofuels are increasing in the Philippines as fossil fuel prices continue to rise.

Economic development has resulted in increased consumption of fossil or nonrenewable energy to the point of dominance, while traditional biomass energy consumption has fallen (Bildirici, 2014). However, in the countries studied by Bildirici (2014), biomass energy has been found to significantly influence economic growth. With this, the author came to the conclusion that biomass energy is a crucial aspect of sustainable economic development.

2.1.5 Solar

According to Hu et al. (2010), solar energy is a clean, environmentally friendly energy source for power generation; but, due to its high cost and high-tech nature, solar photovoltaic electricity generation is not practicable for big commercial scales. In relation to this, Ocon (2019) results show that there is a huge economic potential to shift the diesel generation to solar photovoltaic-battery-diesel hybrid systems, with an average cost reduction of around 20% of the levelized cost of electricity in small island grids in the Philippines. More and more countries are trying to grow their solar capacity in order to minimize carbon emissions and reliance on commodity fuels, help with peak power needs, and create local jobs (Jordan, 2014).

Solar energy has the potential to be a renewable energy source in both electrical and thermal. Solar energy storage, on the other hand, will become critical when solar energy provides a significant portion of total energy due to its unsteady nature, as stated by Hou et al. (2011). Ali et al. (2017) discovered that only a small percentage of African households utilize solid fuels and solar energy for lighting. In comparison to poorer homes, wealthier and more educated households use solar energy. Additionally, it has been found by Rintamaki et al. (2017) that solar electricity reduces price volatility in Germany.

2.1.6 Wind

Grid-connected wind capacity has doubled every three years on average during the last decades of the 20th century. Wind turbine technology has evolved significantly over time as a result of rapid market development (Ackermann & Soder, 2000). Specifically, since 1996, wind energy has been a rapidly growing source of electricity. Despite its benefits, because of its intermittent nature, this energy could never be the main source of electric power to be incorporated into the grid, even in strong wind locations like the Great Plains (Hasan et al., 2013). Wind energy development has been limited by concerns about varying wind speed features, which destabilize the power system (Lucas et al., 2021). Thus, their paper warns that if the share of wind energy generation grows in the future, power system stability in the Philippines may become increasingly vulnerable to wind variability.

Moreover, Barrera (2017) made a formal effort to empirically evaluate the impact of wind farm development projects on the local tourism business. In contrast to the conclusions of international studies, the results reveal that tourists are ready to pay a premium for accommodation with a view of the windmills. Thus, under standard assumptions, these individual positive perceptions of wind farm facilities would translate into an increase in visitor visits in the area, resulting in more money through job creation, tourist spending, lodging, and transportation. Furthermore, the study of Rintamaki et al. (2017) discovered that wind power reduces daily price volatility in Denmark by flattening the hourly price profile.

2.2 Nonrenewable Energy

According to Adewuyi and Awodumi (2020), consumption of nonrenewable energy facilitates output production but is also a major source of carbon emissions, creating a policy dilemma between economic growth and pollution reduction. In the study conducted by them, all of the African countries, with the exception of Algeria, show evidence of an asymmetric effect of per capita petroleum and natural gas consumption on economic growth and carbon emissions. The results of Hou et al. (2019) also show that renewable energy consumption affects CO2 emissions negatively while nonrenewable energy consumption positively impacts CO2 emissions.

Traditionally, fossil fuels have been the primary source of energy, but their usage has a number of negative consequences, including global warming and air pollution (Felgueiras et al., 2018). As shown in Hou et al. (2018) research, in the nonrenewable energy model, natural gas and coal are the primary contributors to Pakistan's pollution level. In the renewable energy model, economic development contributes positively to CO2 emissions, but not in the nonrenewable energy model.

For the Philippines, a net importer of coal, developing self-sufficiency in non-fossil fuel energy was viewed as a method to improve energy security by buffering against shocks to global commodity supply (Guild, 2019). However, the consumption of fossil fuels increases environmental degradation (Fuinhas et al., 2019).

2.2.1 Coal

Coal mining is one of the core industries that adds to a country's economic development while also harming the environment. Energy coal is extracted using both opencast and underground methods, and this has a negative impact on the environment, particularly water resources, because of the massive amounts of mine water discharged (Tiwary, 2001).

Whereas a well-known theorem by Herfindahl states that the low-cost nonrenewable resource must be exploited first. Electricity is generated using both coal and natural gas, but still with coal has the greater contribution to pollution (Moreaux et al., 2008).

China is the world's largest energy consumer, with coal accounting for a greater chunk of total energy consumption. Despite this, it was shown that coal's share of total energy use declined dramatically between 2011 to 2015. Chiu et al. (2020) studied this and came to the conclusion that provinces in eastern and central China should continue to minimize coal use in order to enhance energy performance. Provinces in the western region, on the other hand, should strive for a balance between energy efficiency and coal consumption.

2.2.2 Natural Gas

According to Dujak et al. (2017), natural gas is one of the most important energy resources, and it is growing in popularity as a result of its environmental benefits, such as its lower impact on environmental pollution. Natural gas is a high-thermal and low-emission source of energy. For Lin and Xu (2019), the expansion of natural gas consumption will not only fulfill rising energy demand but will also improve the structure of energy consumption. It was discovered in their study that natural gas consumption has an inverted "U- shaped" nonlinear impact on CO_2 emissions in the eastern region but a positive "U-shaped" nonlinear impact in the central and western regions of China.

In both the short and long run, Apergis and Payne (2010) discovered bidirectional causality between natural gas use and economic growth. Similarly, Arouri et al. (2014) conducted a study in Pakistan, where natural gas is the predominant source of energy. According to the results of the causality test, natural gas consumption and economic growth are complementary. In the European Union, Bilan et al. (2016) found that the association between economic development and natural gas consumption is positive, whereas the association between natural gas consumption and economic development appears to be negative. In line with this, Adewuyi and Awodumi (2020) state that controlling CO_2 emissions in emerging countries, where petroleum and natural gas production and consumption are important drivers of economic expansion, may be difficult as it may stifle economic progress.

2.2.3 Oil

The findings of Bloch et al. (2015) show that coal use causes pollution, but renewable energy use reduces emissions. For oil, however, no substantial causation on emissions has been discovered. As a result, the authors advocate for a transition from coal to oil and renewable energy in order to increase economic and environmental sustainability, as oil is also cheaper than coal in comparison.

The clear findings of Al-Mulali (2011) reveal that oil consumption plays a significant impact in MENA (the Middle East and North Africa) countries' economic growth. On the basis of the cointegration result that CO_2 emission and oil consumption have a long-run relationship with economic growth. In both the short and long run, it was also found that a bi-directional Granger causality exists between oil consumption, CO_2 emissions, and economic growth.

2.3 Link between energy consumption and economic growth

2.3.1 Energy

Chen's (2017) regression model results show that gross domestic product (GDP) positively impacts per capita electricity consumption. According to the paper, rising socioeconomic status leads to higher living standards, which in turn stimulates increased electricity demand, particularly if alternative energy is not available at home. In relation, a correlation test by Chen et al. (2007) found that higher GDP and larger residential space could lead to higher living standards and a higher rate of electrical appliance installation, resulting in higher residential electricity usage. Findings coincide that as a result of household economic affluence, lifestyle will play a significant role in electricity demand.

Chirwa and Odhiambo (2020) conducted research about electricity consumption and economic growth. The result of their study concluded that electricity consumption is an important factor of production in the majority of the countries they chose as their subject. Whereas Leong et al. (2013) has found that demand for electricity in Malaysia is always growing in tandem with its Gross Domestic Product (GDP) growth. A similar relationship has also been found in Poland. According to Kasperowicz (2014), electricity consumption is a pro-growth indicator, indicating that Poland's economic growth is dependent on electricity. On the other hand, Yoo (2006) found unidirectional causality running from economic growth to electricity consumption in Indonesia and Thailand. Due to this, energy conservation policies can be initiated without deteriorating economic side effects in the two countries. This is also true for China (Cheng & Zhang, 2009) and Turkey (Sari & Soytas, 2009), which had also been recommended to pursue conservative energy policies as well as carbon emissions reduction policies.

Moreover, the study of Pamuk (2016) examined the electricity production and consumption demand in Turkey's industrial sector. GDP for mining and quarrying and GDP for manufacturing were taken into account, but it was found that mining was statistically insignificant with electricity. This means that between the two GDPs examined. Only manufacturing was significant with electricity consumption. Moreover, Eapen et al. (2020) investigated the connection between electricity consumption and economic growth in India at state and sectoral levels. Results show a unidirectional causal association between electricity consumption and economic growth in the agriculture sector as well as economic growth and electricity consumption in the industrial sector at the sectoral level.

In contrast to most studies, a nonlinear Granger causality test conducted by Adiguzel et al. (2013) supported their neutrality hypothesis that there is no causal association between electricity use and economic growth in the same country. Therefore, they conclude that Turkey's economic development will not be harmed by energy conservation policies. These findings are said to be consistent with the neoclassical assumption that energy has a neutral effect on economic development. Also, contrary to the widespread belief that electricity consumption spurs productivity, Abokyi et al. (2018) reveal that electricity consumption has a negative impact on the manufacturing sector output in Ghana. This might be explained by the fact that, while Ghana's overall growth in electricity consumption is positive, the share of electricity consumption in the industrial sector continues to decline on average.

Meanwhile, in the Philippines, Ishi and Joutz (2010) found that there is a long-run relationship between industrial electricity consumption and GDP in the industrial sector. The relationship and causality direction between electricity consumption and economic growth is an important issue in the fields of energy economics and policies towards energy use (Hanif et al., 2017). As the Philippines is an emerging market, economic growth is of vital importance to ensure the country's transition from a developing country to a developed one.

Additionally, Ahmad and Jamil (2010) conclude that growth in private expenditures is the cause of rising electricity consumption in the residential sector. Conjointly, Del Rio et al. (2016) findings indicate that increases in retail electricity prices have had detrimental welfare effects, especially among the lower-income population. Thus, it is safe to say that electricity use also has an impact on social issues such as poverty and unemployment. Jamasb et al. (2015) found that there is a long-run negative relationship between energy consumption and poverty level. This emphasizes the importance of energy in poverty reduction and economic development. In addition, Afolayan et al. (2019), who studied the importance of electricity use in reducing unemployment in Nigeria, discovered that energy use has a detrimental effect on unemployment. The findings show a 1% rise in electric power use results in a 0.22% decrease in the level of unemployment. Furthermore, Onuh et al. (2011) state that lower-income households have more elastic electricity demand than higher-income households. The author highlights that understanding how consumers respond to price increases in electricity will help utility providers and policymakers foresee future energy demands and devise effective conservation policies.

Demand for electricity will rise as the economy grows. Quan et al. (2018) emphasize that Hong Kong's commercial sector will particularly experience this; thus, the Hong Kong government would need to consider how to satisfy the growing electricity demand. Hussain et al. (2016), who conducted a study about forecasting electricity consumption in Pakistan, revealed that the demand for electricity would be highest in the household sector, with energy production increasing at a lower rate than overall electricity usage over the forecast period. Along with this, Delima (2019), who projected the Philippines' electric consumption for years of 2018-2022, discovered an evident increasing trend. This increasing consumption is expected for all parts of the world, as supported by Hasan et al. (2012), who states that global energy consumption is expected to rise at a faster rate than global population growth by looking at the current energy demand scenario.

2.3.2 Renewable and Non-renewable Energy

Over the period 1990–2007, a multivariate panel framework was used to examine the link between renewable and nonrenewable energy use and economic development in 80 countries by Apergis and Payne (2012). Pedroni's heterogeneous panel cointegration test revealed a long-run equilibrium link between real GDP, renewable energy consumption, and nonrenewable energy consumption. In both the short and long term, the panel error correction model results revealed bidirectional causation between renewable and nonrenewable energy use and economic development. In addition, there is bidirectional short-run causation between renewable and nonrenewable energy consumption, indicating that the two energy sources are substitutable. Similar to this, Shahbaz et al. (2018), who used Granger-causality testing, also investigated the causal relationship between renewable energy consumption, oil prices, and economic activity in the United States. It was discovered that there is a bidirectional correlation between changes in renewable energy consumption and economic growth. This suggests that increases in renewable energy use lead to increased economic activity. Bowden and Payne's (2020) study included a sectoral analysis, similarly focused on the United States. Their long-run Toda-Yamamoto causality tests show that there is no Granger-causality between commercial and industrial renewable energy consumption and real GDP. Alternatively, there is bidirectional Granger-causality between nonrenewable energy usage and real GDP in the commercial and residential sectors, respectively. Likewise, Fu and Pao (2013) conducted a study regarding renewable energy, nonrenewable energy and economic growth in Brazil. Results show that expanding renewable energy would not only boost Brazil's economic growth and reduce environmental degradation, but it would also provide the country with a chance to take a leadership position in the international system and increase its competitiveness with more developed nations.

On the other hand, Amri (2017) conducted a study about the relationship between economic development and energy consumption in Algeria between 1980 and 2012. The long-run and short-run autoregressive distributed lag (ARDL) estimates suggest that only nonrenewable energy and capital can help boost economic growth, whereas renewable energy has no impact. Furthermore, the findings demonstrate a long-term unidirectional relation between renewable energy and economic growth, capital, and nonrenewable energy. Also, according to the findings of Destek & Aslan (2017), only nonrenewable energy use contributes to economic growth in the Philippines. Aside from the Philippines, the growth hypothesis is also found for China, Colombia, and Mexico in terms of nonrenewable energy use. It has also been reported by Le et al. (2019) that no Granger causality causation exists between carbon emissions, energy consumption, and renewable energy use in the Philippines, Malaysia, and Thailand. Ind

2.3.3 Problems of the industry and policies

Key sustainability challenges in the ASEAN-5, which includes Indonesia, Thailand, Malaysia, the Philippines, and Vietnam, are attributed to satisfying rapid demand growth, improving electricity supply security and reducing CO2 emissions from electricity generation (MacGill et al., 2012). Furthermore, given the ASEAN region's promising resource and technological potential, MacGill et al. (2012) and Erdiwansyah et al. (2019) assert that renewable energy emerges as a viable choice for addressing challenges in the electricity industry. Increasing the share of renewable energy in electricity production, on the other hand, necessitates significant policy support. According to Erdiwansyah et al. (2019), ASEAN governments should take constructive steps such as eliminating fossil fuel subsidies, regional market integration, and accelerated implementation of existing projects in order to meet the ambitious goal of 23% renewables in the primary energy mix by 2025. Ultimately, all of these strategies would require sustained leadership, political will, and tangible actions from stakeholders, especially increased regional cooperation.

Developing non-OECD Asian countries reforms, which includes the Philippines, were implemented against chronic electricity shortages, fiscal constraints, weak institutions, and complex political factors (Jamasb et al., 2017). With electricity demand expected to double in the next two decades, non-OECD Asian reforms would have significant economic and environmental consequences for global energy usage and emissions. As demand for electricity increases with the age of technology, the industry responsible for supplying and distributing must ensure that it can deliver what is needed.

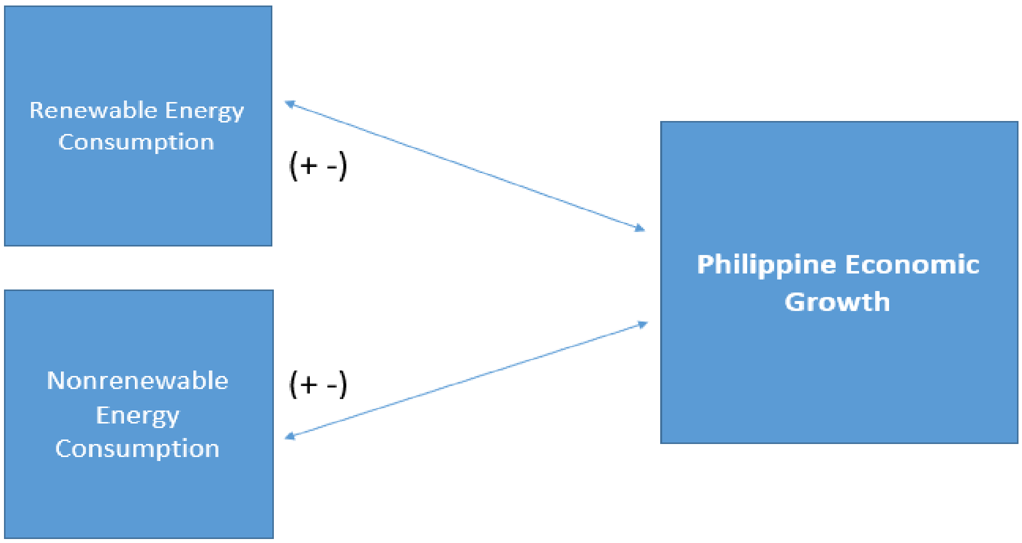
Currently, the Philippines has one of the highest electricity prices for commercial and residential consumers in the ASEAN region, with prices between \$0.12 (commercial) and \$0.20 (residential) per kilowatt-hour (kWh) (Koebrich & Speer, 2019). The primary cause of this expense is said to be a heavy reliance on imported coal and diesel. Nevertheless, Agaton and Karl (2018) believe that the Philippines is progressing towards energy independence by developing more sustainable energy sources. However, investment in renewable energy is hampered by competitive oil prices, very high sustainable energy investment costs, and high local electricity prices. Their study shows that reducing the local electricity price and incorporating negative externality supports investment in renewable energy over continuing to rely on oil for electricity generation.

In acknowledgement of the benefits of using renewable energy as a source of energy, the Philippines implemented new laws to promote its deployment (i.e., the Renewable Energy Act of 2008 and the Biofuels Act of 2006) (Rosellon, 2017). Feed-in-tariffs (FITs) are a common policy instrument for increasing renewable energy growth, wherein the government pays electricity-generating providers a long-term and mutually agreed-upon rate to develop renewable energy such as solar, biomass, wind, and hydropower. In recent years, the Philippines have adopted FITs, resulting in a significant increase in renewable energy in the Philippines (Guild, 2019). However, Marquardt (2017) states that passing the Philippine Renewable Energy Act has not significantly pushed the development of the renewable energy sector or even threatened the dominance of fossil fuels. Moreover, productivity in the electricity sector has not improved significantly despite the reforms instituted in 2001 (Bautista & Valderrama, 2012).

A reliable supply of electricity is essential for economic development (Urpelainen & Yang, 2018). The rapid social and economic progress in fast-developing countries such as those in the ASEAN have driven substantial growth in electricity consumption in the region (MacGill et al., 2012). Therefore, knowledge of the direction of causality between electricity consumption and economic growth is of primary importance if appropriate energy policies and energy conservation measures are to be devised (Bildirici, 2012).

Likewise, the ability to forecast electricity consumption results is critical for managing the needed electricity demand in a variety of industries and other sectors (Dey et al., 2019). As the Philippines has become one of the ASEAN countries with the highest electricity prices for consumers, it is true that improved policies are needed to assist the industry in properly using resources in a period of increasing uncertainty, as well as to assist government officials in better understanding the implications of their regulatory decisions (Kazan et al., 2019). Agaton and Karl (2018) believe that switching to renewable energy is a better choice for a developing country that is heavily reliant on imported fuel than continuing to use imported diesel. As the country relies so heavily on imported fossil fuels, sharp surges in global fuel prices could jeopardise the country's energy security. Thus, renewable energy serves as a long-term solution.

2.3 Research Simulacrum



2.4 Null Hypothesis:

H0: Renewable electricity consumption does not Granger cause GDP per capita; GDP per capita does not Granger cause the renewable electricity consumption

H0: Nonrenewable electricity consumption does not Granger cause GDP per capita; GDP per capita does not Granger cause the nonrenewable electricity consumption

3. Research Method

3.1 Study Design

This is descriptive research that utilized the Granger causality test to analyze the data. In order to satisfy the objectives of this study, a quantitative approach was used to collect the data. According to Tastan (2015), Granger (1969) proposed a model of causality between two variables (or two blocks of data) that is based on two assumptions: 1) The cause happens before the effect, and 2) the cause provides knowledge about the consequence. Granger causality indicates that the causal variable may be used to forecast the value of the effect variable in the future.

The subject of this study is the Philippines, particularly its electricity consumption for both nonrenewable energy and renewable energy. This is a national study as it looks into the electricity consumption of the whole country. The time period of the data is from 1965 to 2019. The per capita electricity consumption by the source was collected in order to calculate the renewable and nonrenewable energy consumption per capita. The dataset is measured in kWh (kilowatt-hours). The data was gathered from Our World in Data, an online database. The World Bank was also utilized for the Gross Domestic Product data, specifically labelled as "GDP per capita (constant LCU) – Philippines". GDP per capita is calculated by dividing the gross domestic product by the midyear population in constant local currency.

This study used different statistical tests to determine whether there is a relationship between renewable energy consumption and nonrenewable consumption to GDP per capita, respectively. The direction of causality was also investigated to determine which of the two types of energy consumption Granger causes GDP per capita of the Philippines. The equation of the Ordinary Least Squares method is as follows:

GDPPC = β_0+ β_1Renewable Energy Consumption + β_2 Non-renewable Energy Consumption+e

3.2 Augmented Dickey-Fuller (ADF)

Most economic time series data have unit roots which show that their means and variances are not time-invariant. If this is the case, a univariate series is said to be non-stationarity and cannot be used for regression with other non-stationary univariate series because of the risk that their results may be biased and misleading. The only exception to this rule is when the time series data of all variables have identical unit-roots.

The widely used unit root test is the so-called Augmented Dickey-Fuller (ADF) test. The ADF test (Dickey and Fuller, 1979, 1981) is used to determine the order of integration of our series, allowing us to infer the number of unit roots contained in each variable (Coughlan, 204). The basic equation for testing the stationarity of a time series is given by the following:

$$\Delta x = \alpha_o + \alpha_1 t + \beta x_{t-i} + \Sigma \varphi \Delta x_{t-i} + \varepsilon_t$$

where the first difference of the series, Δxt, is regressed against lagged of its original level series, time, and lagged values of itself. If the estimated value of β is more negative than MacKinnon critical values, the series is said to be stationary. Otherwise, it is non-stationary and therefore has a unit root. The augmented portion of the test is to correct for any serial correlation in the variable.

3.3 Autoregressive Distributed Lag model (ARDL)

According to the study of Pesaran and Shin (1997), When the variables in the long-run relationship of interest are trend stationary, it is a common practice to de-trend the series and model it as a stationary distributed lag or autoregressive distributed lag (ARDL) model. Following that, the model's long-run properties are estimated and inferred using standard asymptotic normal theory.

$$y_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{p} \emptyset_i \, y_{t-i} + \beta' x_t + \sum_{i=0}^{q-1} \beta_i^{*\prime} \, \Delta x_{t-i} + u_t$$

The mentioned journals of Bildirici et al. (2012), Arouri et al. (2014) and Amri (2017) utilized this method. The ARDL method can be used for both stationary and non-stationary time series with a mixed order of integration. The method will be used in this study to determine the existence or absence of a long-run relationship between electricity consumption of renewable and nonrenewable sources and the economic growth of the Philippines.

3.4 Granger causality

Granger causality is a way to investigate causality between two variables in a time series. Bildirici et al. (2012) acknowledged that the ARDL approach does not indicate causality direction. As a result, their paper used the Granger causality test to examine the causal relationship between electricity use and their respective variables.

To determine the causality between X and Y, if X causes Y or Y causes X, or if there was bi-directional causality, a model was specified. This test will determine the nature and direction of the relationship between the three sectors' electricity consumption and the given variables.

$$\Delta LY_{it} = \sum_{k=1}^{p} \beta_k \Delta LY_{i,t-k} + \sum_{k=0}^{p} \theta_k \Delta LX_{i,t-k} + u_{i,t}$$

$$\Delta LX_{it} = \sum_{k=1}^{p} \beta_k \Delta LX_{i,t-k} + \sum_{k=0}^{p} \theta_k \Delta LY_{i,t-k} + v_{i,t}$$

4. Results and discussion

The study looked into the Philippines' nonrenewable and renewable energy consumption. This is to establish if a Granger causation exists between nonrenewable and renewable energy consumption per capita and GDP per capita in the Philippines. The study employed pairwise Granger causality tests to fulfil the objective of determining whether it is renewable or nonrenewable energy that has a Granger causality with Philippine economic growth.

The equation of the Ordinary Least Squares method is as follows:

GDPPC = β_0+ β_1Renewable Energy Consumption + β_2 Non-renewable Energy Consumption+*e*

Year	GDP per capita (constant LCU)	Renewable Energy per Capita (kWh)	Nonrenewable Energy per Capita (kWh)
1965	64734.06769	139.293	1624.149
1966	65574.9247	132.508	1716.526
1967	67046.68901	142.173	1874.046
1968	68340.29755	141.375	2070.995
1969	69484.70119	144.934	2157.488
1970	70051.94433	162.691	2382.548
1971	71758.21925	145.711	2685.455
1972	73524.39358	161.658	2560.963
1973	77827.1197	168.989	2919.67
1974	78344.71737	141.92	2656.016
1975	80417.7659	152.863	2791.825
1976	85106.73637	182.908	2792.249
1977	87438.04348	134.659	2988.856
1978	89480.7159	174.332	2994.89
1979	91980.64267	212.068	3001.778
1980	94106.85119	326.524	2746.578
1981	94698.66891	435.857	2538.601
1982	95476.5288	426.51	2385.585
1983	94645.25431	481.055	2475.348
1984	85359.06948	559.293	2056.813
1985	77010.20086	588.31	1868.719
1986	77528.12586	577.442	1851.188
1987	78740.49182	492.018	2075.279

1988	81868.41847	542.701	2213.809
1989	84721.21788	561.009	2345.188
1990	85101.91519	536.651	2407.036
1991	82530.17071	477.285	2304.951
1992	80815.19942	433.2	2717.931
1993	80575.21401	446.195	2735.53
1994	82152.83736	496.31	2803.991
1995	84020.80546	492.273	3099.776
1996	86917.72673	527.686	3247.121
1997	89385.26909	506.102	3466.267
1998	86916.60184	520.053	3424.908
1999	87653.84488	670.88	3260.423
2000	89565.66064	691.845	3146.144
2001	90349.24719	607.765	3093.942
2002	91757.76039	582.17	3018.915
2003	94467.08399	580.36	3073.174
2004	98701.73782	603.141	3098.02
2005	101641.4417	570.474	3046.137
2006	105142.1503	622.226	2822.686
2007	110096.5962	559.662	2959.83
2008	112988.5069	599.029	2974.242
2009	112749.3114	573.18	2959.912
2010	119019.3015	494.541	3087.354
2011	121537.6628	538.103	3051.841
2012	127724.8135	550.1	3085.48

2013	134059.2168	515.377	3313.041
2014	140240.8398	501.565	3458.631
2015	146806.7455	519.345	3752.183
2016	154949.6935	533.202	4061.532
2017	163311.7909	551.073	4419.327
2018	171260.68	543.585	4495.219
2019	179276.3245	548.208	4593.292

Table 1. GDP per capita (constant LCU), Renewable Energy per Capita (kWh), and Nonrenewable Energy per Capita (kWh) of the Philippines

Table 1 shows the dataset consisting of the Philippines' GDP per capita in constant LCU and per capita consumption of Renewable Energy and Nonrenewable Energy ranging from years 1965 to 2019. The researchers calculated renewable energy per capita (kWh) and nonrenewable energy per capita (kWh) in the Philippines by calculating the total consumption of renewable and nonrenewable energy sources (kWh). Renewable energy included hydro, wind, solar and other renewables, all in per capita. While nonrenewable energy covered coal, oil, gas and other nonrenewable also all per capita.

The country's per capita consumption of nonrenewable energy is dominant over renewable energy. As seen in the table above, nonrenewable energy is always far higher than renewable energy. This coincides with the fact that the Philippines lacks renewable energy sources.

Pairwise Granger Causality Tests
Sample: 1965 - 2019
Lags: 1

Null Hypothesis	Obs	F-Statistic	Prob.
D (NONRENEWABLE ENERGY PER CAPITA KWH) does not Granger Cause DLOG (GDP PER CAPITA CONSTANT LCU)	53	0.04729	0.8287
DLOG (GDP PER CAPITA CONSTANT LCU) does not Granger Cause D(NONRENEWABLE ENERGY PER CAPITA KWH)		0.88848	0.3504
D (RENEWABLE ENERGY PER CAPITA KWH) does not Granger Cause DLOG (GDP PER CAPITA CONSTANT LCU)	53	0.51694	0.4755
DLOG(GDP PER CAPITA CONSTANT LCU) does not Granger Cause D(RENEWABLE ENERGY PER CAPITA KWH)		0.34813	0.5578
D(RENEWABLE_ENERGY_PER_CAPITA_KWH) does not Granger Cause D(NON-RENEWABLE_ENERGY_PER_CAPITA_KWH)	53	1.49990	0.2264
D(NON-RENEWABLE_ENERGY_PER_CAPITA_KWH_) does not Granger Cause D(RENEWABLE_ENERGY_PER_CAPITA_KWH_)		0.12831	0.7217

Table 2. Pairwise Granger Causality Tests

Table 2 shows the results of the Granger Causality Tests. Based on the data above, we must accept all null hypotheses since all p-values are greater than the 5% level of significance. In line with F-statistics that are close to 1, we accept all null hypotheses that state that there is no causality between GDP per capita and its independent variables, renewable and nonrenewable energy consumption per capita. Thus, the independent variables do not Granger cause the dependent variable.

These results are the same in Turkey as found by Adiguzel et al. (2013). The neutrality hypothesis was supported that there is no causal association between electricity use and economic growth. It was then concluded that Turkey's economic development would not be harmed by energy conservation policies. The same can then be said for the Philippines. These findings are said to be consistent with the neoclassical assumption that energy has a neutral effect on economic development (Adiguzel et al., 2013). Since energy consumption does not Granger cause GDP, this implies that economies are not energy-dependent, and thus energy use is not required to stimulate growth.

Dependent Variable: DLOG(GDP_PER_CAPITA_CONSTANT_LCU_)

Method: ARDL

Sample (adjusted): 1967 – 2019

Model selection method: Akaike info criterion (AIC)

Fixed regressors: C

Number of models evaluated: 100

Selected model: ARDL (1,0,0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(GDP_PER_CAPITA_CONSTA...	0.509936	0.104496	4.879972	0.0000
D(NON-RENEWABLE_ENERGY_PER_...	7.55E-05	2.01E-05	3.749983	0.0005
D(RENEWABLE_ENERGY_PER_CAPI...	5.61E-05	7.58E-05	0.740210	0.4627
Constant	0.005076	0.003913	1.297229	0.2006

R-squared	0.495222	Mean dependent var	0.018976
Adjusted R-squared	0.464317	S.D. dependent var	0.031981
S.E. of regression	0.023407	Akaike info criterion	-4.599061
Sum squared resid	0.026847	Schwarz criterion	-4.450360
Log likelihood	125.8751	Hannan-Quinn criteria	-4.541878
F-statistic	16.02412		
Prob(F-statistic)	0.000000	Durbin-Watson stat	1.752226
*Note: p-values and any subsequent tests do not account for model selection			

Table 3. Autoregressive Distributed Lag (ARDL) model

A significant positive relationship exists between GDP per capita and nonrenewable energy. However, none is found for renewable energy. This is shown by their p-values in Table 3. Therefore, you can expect that an increase in nonrenewable energy consumption will increase GDP per capita in the country. This proves that the Philippines has been experiencing rapidly increasing electricity demand, which is expected to be met mostly by coal. It also shows that the Philippines is reliant on nonrenewable energy.

The values of the Durbin-Watson, Akaike information, Schwarz, and Hannan-Quinn criteria all indicate that the regression model is error-free. R-squared and Sum squared residuals show similar results. The model fits the data well, which means it delivers an accurate interpretation.

The paper's findings coincide with Destek and Aslan's (2017) that found only nonrenewable energy use contributes to economic growth in the Philippines. They also found that this is the same case in China, Colombia, Mexico. Moreover, nonrenewable energy was found to help generate economic growth in Algeria, whereas renewable energy has no impact (Amri, 2017)

Variance Inflation Factors

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
DLOG(GDP_PER_...	0.010919	1.401938	1.046018
D(NON-RENEWABL..	4.06E-10	1.341032	1.225420
D(RENEWABLE_E....	5.75E-09	1.216682	1.182487
Constant	1.53E-05	1.480925	NA

Table 4: Variance Inflation Factors

Table 4 shows how much the behaviour of the independent variable is correlated with the other variables. Based on the results shown above, nonrenewable and renewable energy per capita is moderately correlated with each other.

Series: Residuals	
Sample 1967 - 2019	
Observations 53	
Mean	1.31e-19
Median	0.001433
Maximum	0.056048
Minimum	-0.076664
Std. Dev.	0.022722
Skewness	-0.573848
Kurtosis	4.738842
Jarque-Bera	9.585888
Probability	0.008288

Table 5: Jarque-Bera Tests Results

Table 5 shows the Jarque-Bera Tests, which indicate if the sample data is from a normal distribution. Based on the results, the skewness of the sample data suggests that the distribution is not symmetrically distributed since the value is not between –0.5 and 0.5. The skewness tells us that the distribution of the data is not symmetrical, meaning that the values of the variables such as the mean, median, and mode appear at irregular frequencies. On the other hand, the kurtosis shows that the dataset has heavier tails than a normal distribution.

Breusch-Godfrey Serial Correlation LM Test:

Null Hypothesis: No serial correlation at up to 1 lag

F-statistic	1.601326 1	Prob.F (1,48)	0.2118
Obs*– squared	.711049	Prob. Chi-square (1)	0.1908

Table 6: Breusch-Godfrey Serial Correlation LM test

Table 6 shows that the p-value that corresponds to this test is greater than the 5% significance level, which means that we must accept all null hypotheses. This also suggests that there is no autocorrelation among the residuals.

Heteroskedasticity Test: ARCH

F-statistic	3.159025 3.0	Prob. F (1,50)	0.0816
Obs*R– squared	90148	Prob.Chi-square (1)	0.0788

Table 7: Autoregressive conditional heteroskedasticity (ARCH) model

This table shows the future volatility in the time series. Results show that there is no forecasted high or low volatility in the data. The null hypothesis must be accepted in the Chi-square test since the p-value is greater than 0.05. The r-squared indicates that 30% of the data fit the regression model.

Ramsey RESET Test

	Value	Df	Probability
t-statistic	1.177123	48	0.2450
F-statistic	1.385619	(1,48)	0.2450
Likelihood ratio	1.508288	1	0.2194

Table 8: Ramsey RESET Test

Table 8 shows the Ramsey Reset test. The results show that there is no nonlinear relationship between the independent and dependent variables since the p-value for f-statistic is higher than the 5% significance level. This also indicates that we cannot reject the null hypothesis.

5. Conclusion and Policy Implications

According to Bildirici (2012), understanding the direction of causality between electricity consumption and economic growth is critical in developing suitable energy policies and energy conservation measures. This study investigated the causal relationship of renewable energy and nonrenewable energy consumption to the economic growth of the Philippines. A Granger causality test was used to examine the causality between energy consumption and economic growth. As a result of the analysis, we accepted the null hypothesis that there is no causal relationship between renewable energy and nonrenewable energy consumption per capita and GDP per capita, implying that neither GDP nor renewable energy and nonrenewable energy consumption Granger cause each other.

The nonexistent Granger causality indicates that energy conservation policies implemented in the Philippines will not have a significant negative influence on the country's economic growth. This indication is supported by Adiguzel et al. (2013), who also found no causal association between electricity use and economic growth in Turkey using a nonlinear Granger causality test. One example of a policy is the Energy Efficiency and Conservation Act or Republic Act No. 11285 of 2018 that aims to institutionalize energy efficiency and conservation, enhance the efficient use of energy, and grant incentives to energy efficiency and conservation projects in the country.

The study found that an increase in nonrenewable energy consumption will increase GDP per capita in the country. However, the same cannot be said for renewable energy. The Philippines relies on costly nonrenewable energy as its primary source of electricity (Koebrich & Speer, 2019). Given the country's limited renewable energy initiatives, this may be one of the reasons why the researchers did not find a significant Granger causality between renewable energy consumption and GDP per capita. Even if a causal relationship was not found, researchers still recommend that the country continue pursuing renewable energy as a source of electricity. This is due to renewable energy's numerous advantages. For one, it is more sustainable as compared to the consumption of fossil fuels which increases environmental degradation (Fuinhas et al., 2019). The findings of Blotch et al. (2015) also state that coal causes pollution while the use of renewable energy reduces emissions. As per Koebrich & Speer (2019), the country is experiencing a shortage in the supply of domestic oil and coal; thus, renewable energy can be a suitable alternative. This leads the researchers to urge the government to continually give significant support and attention to the renewable energy industry.

Furthermore, initiatives to reduce carbon emissions are suggested, which are beneficial to the environment and public health. This can be related to Shahbaz et al. (2018) suggestions about improving energy efficiency. Renewable energy sources are labour intensive, meaning they spend more on hiring people. If persistent usage of renewable energy is implemented, it can help struggling citizens of the country to have a source of income to fund and support their needs. This would be helpful because we faced many economic losses due to the pandemic. The implementation of renewable energy use would benefit the economy and the environment, and the livelihood of the people.

To conclude, energy consumption has no Granger cause effect on GDP in the Philippines. Nonrenewable energy use was found to positively impact the GDP; however, the relationship is not bidirectional, implying that energy use is not required to stimulate growth. With all of this, the researchers would like to say that the results of the study may be affected by the sample period, variables chosen, and methodology used. This also indicates the sensitivity of Granger causality, which is why results based on Granger causality should be interpreted with care. This study can be improved by including more relevant variables such as energy price and population and choosing a smaller sample period where renewable energy was significantly used.

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