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Global strategic innovations in the energy sector

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Abstract. The energy sector is undergoing a rapid transformation and there are many observable signs as to the rapid development of the industry. Many governments around the world have begun to invest in legislation to incorporate sustainable energy and technologies. Hence, they are able to tap the potential of new technological innovation and energy systems. This paper examines energy innovations globally with a particular focus on Saudi Arabia, Malaysia, Indonesia and China.
Keywords. Global strategy, Innovations, Energy sector.
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1. Introduction

An important global sustainable goal is improving quality of the economy, technology and human well-being within resource and environment limits. Therefore, there is much research on eco-efficiency (EE), eco-technology innovation (ETI) and eco well-being performance (EWP) for improving the efficiency of converting ecological consumption into economic benefits technological innovation and human well-being. The results of the paper indicate that countries with high levels of economic development have much better EE, ETI and EQP levels than low-income countries (Yu, Liudan, Chenyand, & Heshan, 2021).

The global economy has climbed from 1.37 to 85.93 trillion dollars during the period from 1960 to 2018. However, this rapid economic growth has resulted in excessive consumption of resources and ecological problems. Example of an increase is that the total primary energy supply (e.g., coal, natural gas and oil) has increased from 8.8 to 13.9 billion tons over the past thirty years. At the same time, it was reported that global greenhouse gas emissions have increased nearly 2 times over, nitrous oxide emission have increased 1.5 times over from 1970 to 2012 and the forest area has decreased by nearly 1.3 million from km^2 from 1990 to 2016. Meanwhile many countries such China, India and the USA have suffered severe air pollution (Yu, Liudan, Chenyand, & Heshan, 2021).

Even though GDP is produced by resources, labor and capital in human economic activities. However, these activities concurrently trigger negative impacts on the environment and unavoidable lead to environmental pollution such as solid waste, air pollution and waste water. Hence, when studying the win-win balance between global economic development and

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environmental protection is both important and meaningful. Eco- Efficiency (EE) is a valuable too for measuring the level of sustainable development, as it is directly connected economic resource and environmental impacts. Moreover, eco efficiency provides a direction for examining sustainability, as it reflects the capacity to produce more desirable output such as GDP, while consuming fewer natural resources and less ecological havoc (Yu, Liudan, Chenyand, & Heshan, 2021).

Furthermore, it is also essential to guarantee that the resources, labor and capital inputs are efficiently converted into technology innovation and human well-being levels in different countries. Eco-technology innovation (ETI) and eco-well-being performance (EWP) require producing more technology and improving human well-being, while decreasing the consumption of resources and eco-environmental impact. Hence, the analysis of EE, ETI and EWP (3E) in different countries could provide a new research perspective for governors to promote global sustainable development. Hence, the aim of this study is to depict sustainable development in different countries in terms of eco-efficiency, eco-technology innovation and eco-well-being performance. The study innovatively evaluates 3E performance in 102 individual countries. The results of this research support effective policymaking to incentivize sustainable development worldwide. The paper also offers a new perspective on the exploration of ecological efficiency considering technology innovation and human well-being indicators, which expands the ecological efficiency literature (Yu, Liudan, Chenyand, & Heshan, 2021).

Eco-Efficiency: Eco-efficiency (EE) which accounts for natural resources, the economy and eco-environmental impacts is usually used to examine sustainability performance at the industrial, regional and national levels. An extended data envelopment analysis (DEA) model can also explore EE performance as was done for Chinese regions during the period from 2000 to 2010. The studies suggested that the Chinese government should simultaneously improve management and technology levels to build an ecological civilization. The DEA model examined the EE of 21 cement industries in different countries. The results suggest that countries with strong environmental regulations such as European countries were the most efficient performers. Furthermore, the DEA model was used to explore Chinese cement manufacturers, EE performance, suggesting that China should reduce pollutant emission by adopting advanced technology. The two stage Super SBM model can also be used to measure EE as was done for 21 countries in Guangdon province China. Other studies have included EE evaluation of 22 OECD countries showing that Hungary, Turkey and the US exhibit poorer EE performance and that Switzerland is the highest efficient country (Yu, Liudan, Chenyand, & Heshan, 2021).

Eco-Technology Innovation: Eco-technology innovation (ETI) which plays an essential role in decoupling environmental problems and economic development is considered an important facilitator of economic growth. Hence, ETI is defined as the generation of new services, processes, products

and systems that greatly increase economic growth but offer a decrement in environmental pollutants. Therefore, ETI has obtained importance in the literature because it adds value to company, city and country competitiveness and moves towards sustainability. Based on the DEA model, explored eco-technology innovation in OECD countries indicating that Switzerland, Ireland and Iceland are the top three eco-innovative countries. Similarly, the two-stage DEA model to study the eco-technology innovation performance of 34 OECD countries using high-technology exports, and electricity production as indicators of ETI (Yu, Liudan, Chenyand, & Heshan, 2021).

Eco-well-being-performance: Eco-well-being performance (EWP) which focuses on improvements in human well-being rather than the growth of traditional GDP is defined as the efficiency of converting natural resources into human well-being while producing less environmental pollution. The 3E model has been used to measure the performance at the city, industrial and regional level. Nevertheless, few studies have assessed EE, ETI and EWP at the global level (Yu, Liudan, Chenyand, & Heshan, 2021).

Two Stage Super SBM Model

We can utilize the proposed two-stage Super SBM model for estimating the global EE, ETI, and EWP, a set of inputs, intermediate products and outputs should be selected. According to previous studies, the input indicators should capture the consumption of natural resources, such as energy consumption land area and water consumption. Additionally, the labor force is commonly selected as a non-energy input. Environmental impacts, including wastewater emissions, solid waste emissions, Sox and NOx emission, PM2.5 air pollution, industrial dust emission, and greenhouse gas emission are commonly selected as emblematic undesirable output in measuring EE, ETI and EWP (Yu, Liudan, Chenyand, & Heshan, 2021).

Analysis of global eco-efficiency

The analysis shows that 12 countries have EE values greater than 1 and are therefore Group 1: Singapore, the US, Switzerland, China, Luxemborg, the Netherlands, Japan, the UK, Norway, France, Brazil and Germany. Amont the 12 countries, there are 10 countries at the HI level, excelpt China and Brazil at the UMI level. This suggests that environmental protection mechanisms and energy-saving techniques are more advanced in highly economically countries. (Yu, Liudan, Chenyand, & Heshan, 2021).

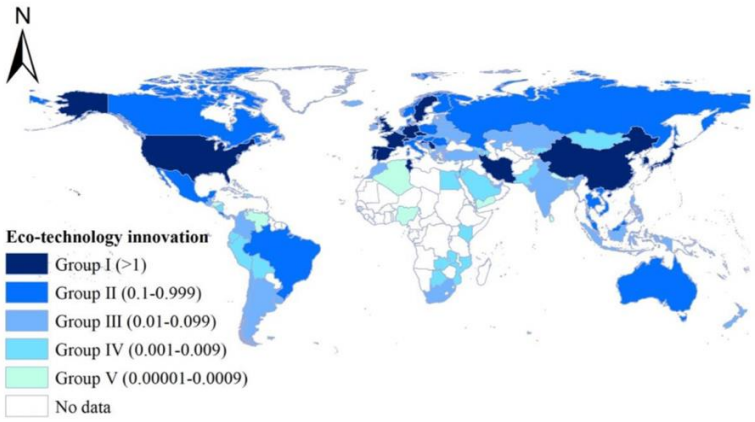
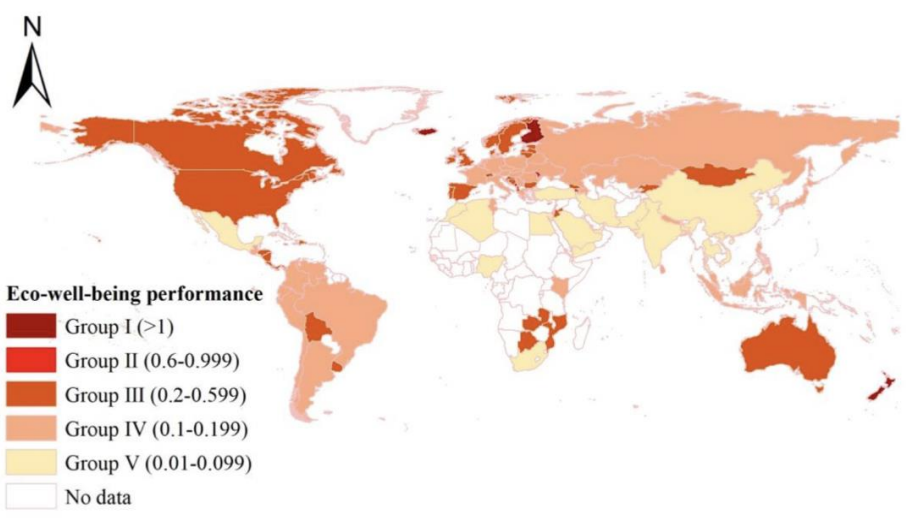


Fig. 5. The overall eco-technology innovation performance of the 102 sample countries.

Analysis of global eco-technology innovation

17 out of the 102 countries have ETI values greater than 1 and are in Group I. These 17 pioneering countries include the US, the Republic of Korea, Singapore, Switzerland, China, Japan and Germany there are also 13 HI level countries and 3 UMI level countries. It is noteworthy to note that most countries are in Groups II, IV and V with eco-technology innovation values lower than 0.1. The findings suggest that overall ETI performance is low across the world, suggesting that most countries need to focus on green technology innovation, especially technologies for energy-saving and environmental protection. It is all worth noting that countries in Africa and Asia present poorer ERI performance than those in Europe. In general, their lower economic level means there are limited resources for promoting the development of technology innovation in many African and Asian countries (Yu, Liudan, Chenyand, & Heshan, 2021).



Analysis of global eco-wellbeing performance.

There are only 6 countries that have EWP values greater than 1 and are in Group 1 including Iceland, Montenegro, Brunei, Darussalam, Malta, New Zealand and Finland. Surprisingly, some HI and UMI level countries have lower EWP values and ranks. Hence, US, China and Japan have large scale economies but the EQP values in these three countries are ranked 32. 54 and 101 respectively. The findings are similar suggesting that many developed countries have lower values in terms of the index of ecological well-being performance values. The distribution of global resource consumption and pollutant emissions are polarized, which leads to disparities in EWP performance in countries with different income levels. China has the largest carbon emissions, similarly US and Japan are also among the top five carbon emitters in the world. (Yu, Liudan, Chenyand, & Heshan, 2021)

2. Nexus between natural resources, technology innovation, green energy and financial performance in the Saudi Arabia: Evidence from asymmetric causality test.

The global financial crises and the volatilities in oil prices caused a severe negative impact on the Saudi Arabia's earning hence government initiated the policies to decrease its oil dependence and recognized the substantial role of the financial sector Hence, the goal of the study is to recognize the potential role of natural resources, green energy and technological innovations influencing the performance of the financial sector in the Saudi economy. The results confirm that positive shocks of natural resources and technology innovation increase the financial performance in Saudi Arabia whereas the positive and negative fluctuations in green energy have a positive and significant impact on financial performance. Proper allocation for natural resources for improving financial performance is recommended whereas more attention is need to improve technology innovation (Alsharif, & Tong, 2020).

The progress of the financial sector supports technical advancements that decline the cost of information and borrowing, along with introducing reforms in institutional quality. In this regard the role of technological innovation is crucial in leading financial growth. Through innovation the financial sector is likely to benefit from cost reduction, resource allocation and efficient evaluation of administrative and financial projects. It further resulted in enhancing the capability of mobilizing savings and investments and thus stimulates growth, especially in emerging economies (Alsharif, & Tong, 2020).

The benefits of an efficient financial sector lie in the ability to support investment decision of the organizations permitting economies to perform effective management of resources and motivating technological advancements to boost growth. On the other hand many studies establishes that the growth of the financial sector carries a negative environmental impact by enhancing energy dependence in both developing and developed

economies, whereas rise in financial sector performance augments energy demand in the resource dependent economy of Saudi Arabia, thus leading to establishing a positive financial sector expansion in the form of resource allocation and technology spillover flourishing growth by also carries a negative impact on the environment by enhancing energy intensity in the financial structure leading to threatens the country's prospect of sustainable development (Alsharif, & Tong, 2020).

In the current era the significance of environmental sustainability is among the top priorities of several economies. Considering the inevitable role of energy utilization in the country's growth, the role of green energy offers a solution to meet the economic need of the energy in a country by exerting minimal pressure on the environment. The link between the financial sector and green energy is also strengthened by witnessing the upsurge in the investments of green energy projects that can avail energy efficiency along with offering due protection to the environment. Furthermore, it has also been state that the eco-friendly financial sector is encourage by offering subsidies to innovating technologies and R&D plans of green energy that can sustain the country's energy needs without dismantling environmental conditions. Hence, the benefits of financial advancements are ascribed from the smooth distribution of resources and investments that can carry positive spillovers into numerous industrial and service sectors of the country, as well as on environment through channeling energy needs in silver, natural gas, iron core, phosphate, tungsten copper, zinc, Sulphur etc. (Alsharif, & Tong, 2020).

The country is included among the top twenty economies of the world. The economy of Saudi Arabia is exclusive for being extensively resource dependent and earns 75 percent of the revenues from natural resources. Also, Saudi Arabia is believed to the Energy Superpower for being the largest exporter of oil in the world while owing second largest petroleum and fifth-largest natural gas reserves with a total worth of 33.2 trillion dollars. Hence, the role of natural resources in molding Saudi Arabia's financial structure is pertinent as they underlie the potential to upset financial development which can carry a negative impact on the country overall growth (Alsharif, & Tong, 2020).

In conclusion the objective of the study is to analyze the empirical significance of the factors that contribute to the financial sector development of Saudi Arabia. In this regards the goal of the study is to recognize the potential role of natural resources, green energy and technological innovations in influencing the performance of the financial sector in the Saudi economy. The findings indicate that all variables have significant and asymmetric impact on financial performance in Saudi Arabia. Moreover, the results confirm that positive shocks of natural resources and technology innovation increase the financial performance in Audi Arabia however the positive and negative fluctuation in green energy have a positive and significant impact on financial performance. The asymmetric causality confirmed a unidirectional causal connection from natural resources to

financial performance however a bidirectional causal connection is found from technology innovation and green energy to financial performance and vice versa. The policy makers need a proper allocation for the natural resources in order to improve financial performance Moreover, the government should pay more attention to improve technology innovation strategies which will also help to improve the generation of green energy that ultimately boost the financial performance of Saudi Arabia (Alsharif, & Tong, 2020).

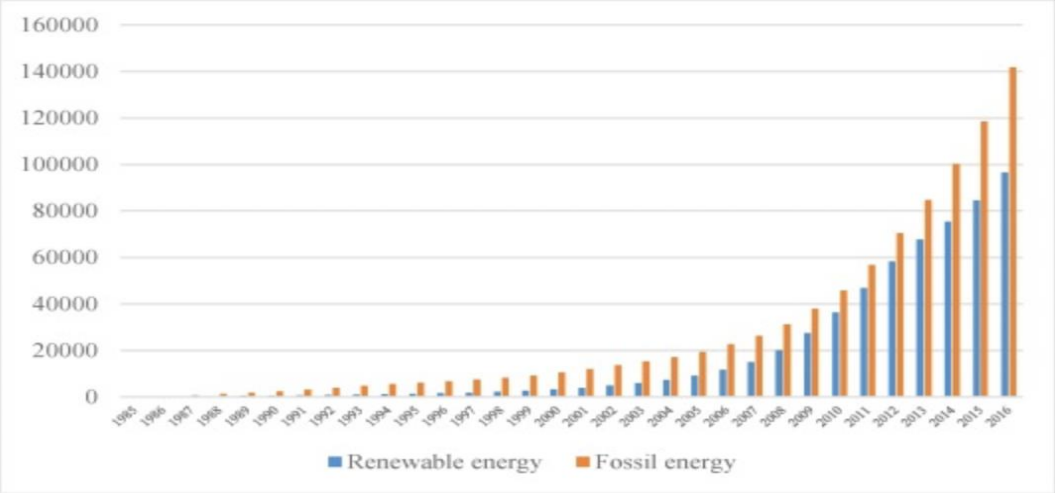
3. Influencing factors of energy technical innovation in China: Evidence from fossil energy and renewable energy

Based on China's provincial panel data from 2001 and 2015, the drivers of energy technological innovation, e.g.: energy price, public financial policy, knowledge sticks, energy structure and environmental regulation are analyzed by using the generalized method of moment (GMM). Hence, there is an empirical analysis that influence factors of energy technological innovation from perspective of fossil energy and renewable energy. The specific conclusion obtained in this paper are: 1. The impact of the energy price on fossil energy technological innovation is greater than renewable energy, which means that the current energy price in China is much lower than its optimal level and the development of renewable energy technology innovation heavily relies on governmental policy support. (3) The accumulation of energy technology innovations will be conducive to the vertical spillover effect of knowledge and further encourage the development of energy technology (Yulin, Zhihui, & Xingmin, 2018).

Climate change has had widespread influence on agriculture distribution of water resources, forest eco-system, coastal sea level and human health in China. As the biggest developing country studying energy technological innovation is an important channel for China to achieve sustainable development. Firstly, energy technology innovation is conducive to industrial restructuring and upgrading. The energy-intensive industries in China such as steel, petrochemical industry, building materials industry power generation and coal mining and processing will continuously exist in the near future. Traditional industries often have the characteristics of high energy consumption and high environmental pollution. Therefore, technological progress can promote energy saving and emissions reduction for these energy intensive industries because it can effectively improve energy efficiency. What's more, energy technology progress helps to promote the development of strategic emerging industries which have higher energy efficiency. This is because mastering core technologies has primary impact on the development of emerging industries. Hence, the development of energy technology innovation gives impetus to emerging industries. such as new energy industry and energy saving & environmental protection industry (Yulin, Zhihui, & Xingmin, 2018).

Emerging industries which play an important role in industrial restructuring and upgrading rely on technological breakthroughs and have a significant effect on economically sustainable development. Secondly, energy technology innovation can effectively optimize China's energy consumption structure. The massive burning of fossil fuels has caused severe environmental pollution problems and China has consumed the largest amount of fossil energy and emitted a lot of CO2 in the world. If the energy consumption in China does not change, the environmental pollution problem will become more prominent. Energy technical progress can effectively increase the proportion of renewable energy consumption since it can reduce costs of renewable energy and stimulate the commercial application of renewable energy. Thirdly energy technology innovation can reduce the external cost of the environment due to the use of fossil energy in the social production process. The coal-based energy structure in China has led to a large number of emitted pollutants as well as serious external environmental costs which then post a huge challenge to the sustainable development of the Chinese economy. Therefore, green technology innovation can better achieve the goal of energy conservation and emission reduction in the whole process of production, thus effectively dealing with environmental externalities (Yulin, Zhihui, & Xingmin, 2018).

In China, fossil energy has dominated the energy structure and emitted a large number of greenhouse gases for a long time. In addition to developing renewable energy, improving fossil energy efficiency is also one of the most effective ways for energy-saving and emission reduction. Therefore, it is really important to develop fossil energy techniques. In general, this paper contributes to the existing literature in the following three aspect: Firstly, we search the number of energy patents for different energy types by using the latest patent code, which accurately reflect the existing energy technological innovations. Secondly there is a huge difference between the development of renewable and fossil energy due to their different status in the national economy and society. Thirdly the influencing factors of energy technological innovation from two aspects and provide some empirical results for induced innovation theory and technology-push innovation theory which enrich literature on these two different innovation theories (Yulin, Zhihui, & Xingmin, 2018).



In conclusion as there is global climate change, it is of great theoretical and practical significance to study the influencing factors of energy technological innovation. Hence, the paper provides empirical evidence for induced innovation theory and technology push innovation theory but also provide some policy proposals to promote energy technological progress. The impact of energy prices, government science and technology expenditure, technological knowledge stock, energy structure and environmental regulation on energy technological innovation from two side of renewable energy technologies and fossil energy technologies. The energy price has different impacts on different types of energy technological innovation. The adjustment of energy price has a greater significant impact on the development of traditional fossil energy technology than renewable energy technology. Compared with fossil energy, the advantage of renewable energy technologies are renewable resources and environmental benefits. In conclusion renewable energy cannot compete with traditional fossil energy in the economy and application scale for a long time, and the development of renewable technologies requires the support of energy price. The implementation of R&D and the promotion of energy technologies require the government financial support (Yulin, Zhihui, & Xingmin, 2018).

Energy technological innovation has great benefits for the environment and society but it also needs a largen umber of investments in the early stages of development since there are certain risks and uncertainty in the R&D. Therefore, the government should play a leading role to promote the large-scale application of renewable energy technologies and publish some policies to encourage enterprises to invest in the R&D. The existing knowledge stock has a positive impact on promoting the innovation of energy technologies. The benefits brought from technological innovation cannot be exclusively owned by innovators and the existing knowledge stock will enable the later researchers to bear lower research costs and risks than previous innovations. Therefore, improving the capability of independent innovation and localization of energy technologies can exert the vertical spillover effect of knowledge and stimulate further research.

Fourthly this paper shows that environmental regulation can promote the progress of energy technology. This result illustrates that environmental regulation is not only economically efficient but also is consistent with the concept of sustainable development (Yulin, Zhihui, & Xingmin, 2018).

4. Influencing factors of energy technical innovation in China: Evidence from fossil energy and renewable energy

This study extends the Marshallian demand framework to investigate the effects of TI (technological innovation) on energy use in Malaysia. This extended frameworks predicts that TI an exogenous element in the energy demand function, increases energy efficiency and correspondingly, reduces energy consumption at a given level of economic out. Controlling for the effect of TI this study finds that increasing GDP per capita and trade openness produce a rebound of TI on energy use. Although trade has continuously accounted more than 100% of GDP in Malaysia since the early 1980s the impact of trade on energy use in Malaysia has not been studies; hence, this article incorporates trade openness into an energy function to explore this nexus. TI (technological innovation) is crucial for improving energy efficiency. Although there are other methods of promoting energy efficiency, such as market-based approaches policies and controls the magnitude of the impact of technological innovation. Malaysia has experienced considerable technological innovation with its rapid growth, moving towards achieving developed national status by 202. There is a trend of increasing technological innovation (as measured by the number of patents) in Malaysia from 1980 to 2012 (Fang, Yuanyan, & Xin 2019).

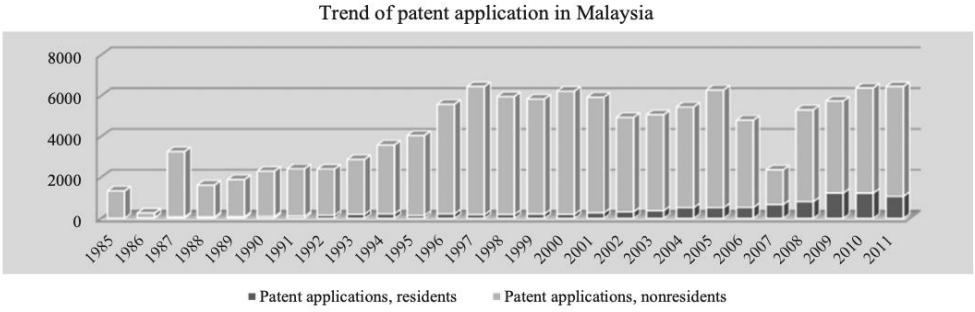


Fig. 4. Trend of patent application in Malaysia.

Trade openness facilitates the penetration of technology from developed countries into developing countries. Technological diffusion promotes energy efficiency when the diffusion takes place through trade openness in the context of European Union member countries. However, measure of trade openness, economic growth and human development influence energy use in the economies of Thailand, Indonesia and Malaysia. In regards to the nexus between technological innovation energy efficiency, technological increases the quality of production by augmenting energy efficiency in fact, OECD countries experience greater energy efficiency gains due to their

sizable technological innovation compared to their developing countries. Outside the OECD found an inverted U – shaped relationship between household final consumption and residential CO2 emissions due to the use of advanced household technologies in Malaysia. Technology may reduce energy efficiency marginally however in absolute terms, it may produce a rebound in overall energy use (Fang, Yuanyan, & Xin 2019).

As an emerging country in Asia, Malaysia is experiencing smooth increasing trend in GDP (per capita). Energy uses per capital is constantly increasing with the changing of growth patten of Malaysia. Due to the domination of sophisticated industrial and service sectors in the Malaysia economy, energy use has increased on a large scale. The development of information and communication technologies as well as technology-based household entertainment compounds energy use. Malaysia is a country thriving in trade, which is considered a prime growth engine, indicates that trade has persistently remained at over 100% since 1998 to 2012. It can be argued that local energy demand is largely derived from trade in Malaysia. The number of patents could be considered a proxy for technology innovation because it indicated the interest of industrial and private organizations in exploring a new technology. In addition, states that technology innovated can be reflected by a quantitative indicator such as the number of patents (Fang, Yuanyan, & Xin 2019).

The article demonstrates that rapid economic growth (eg., GDP per capita) and trade openness are significant factors in increasing energy use in Malaysia during the study period. However, technological innovation helps to reduce energy use by increasing the energy efficiency of production process, which ultimately reduces emissions. The empirical analysis of this study has produced sever interesting findings. Firstly, the increase in GDP per capita augments energy use over both the short and long run in the Malaysian economy. However, the magnitude of the impact of GDP per capita on energy use is higher over the long run than over the short run. Secondly trade openness also increases domestic energy use over the long run in the Malaysian economy. The findings indicate that technological innovations play an important role in reducing energy use and improving energy efficiency. The largest emerging economies have all built effective systems for the development and deployment of new technologies including low emissions technologies. Thus, policy makers can take serious action on climate change mitigation by improving energy efficiency and increasing the share of renewable energy use in the energy sector. (Fang, Yuanyan, & Xin 2019).

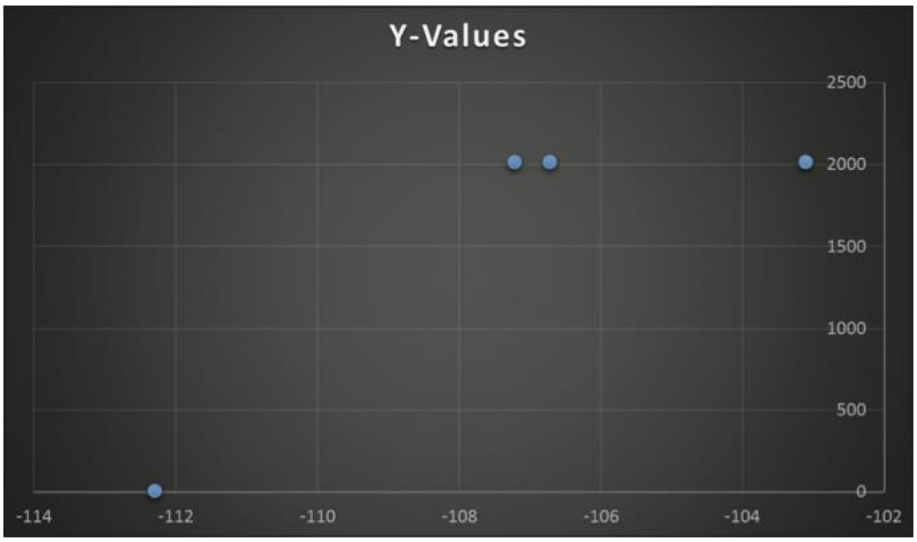
5. Ensuring renewable energy consumption through innovation R&F and Energy import in Indonesia: A Time series Analysis

Energy resources have now been scarce as the use of energy has been increased. There is a need to manage resources in Indonesia there has been

depletion of these resources accordingly and for this there has been a proposed solution which is to go for the renewable energy resources and energy consumption. Therefore, this research sets the propositions as how factors like innovation resource development and the imports of energy can help ensure renewable energy consumption in Indonesia for the period of 1995-2019. The independent variable for research are innovation, research and development and energy import. The dependent variable is renewable energy consumption and the control variables are population growth and energy consumption. The research proposes significant implications for policy makers to make effective policies for R&D and for the companies to go for innovation as to use renewable energy. The utilization of renewable energy has been increased globally with the replacement of conventional non-renewable energy sources such as fossil fuels comprising diesel, gasoline, coal etc. The emerging economies and countries focused on the integration of renewable energy sources including solar, wind, hydropower, geothermal and biomass in order to achieve sustainable energy goals and its growth. As in the prevailing competitive environment and limited non-renewable energy sources the generation of renewable energy is considered as the driver of the economic growth and advancement. It is regarded as the essential resource of the country and plays a key role in the improvement of economic and social standard of living. Globally the bulk of energy consumed is shifting from non-renewable energy, such as oil/gas and coal to renewable energy sources such as solar hydropower geothermal and biomass (Purwanto, Sinaga, Hayati, & Sidik, 2021).

The rising trends of advanced technology rising costs for non-renewable energy imports, limited non-renewable resources, environmental concerns and governmental focus towards sustainable energy and preservation of natural environment resulted in generation of renewable along with the high governmental funding due to the concern of protecting the environment boost the renewable energy growth and its market. The technological advancement makes innovation the prominent sources of economic development and a source to get competitive advantage as energy is the essential requirement in every production process and determines the total production output and supply patterns of the country (Purwanto, Sinaga, Hayati, & Sidik, 2021).

Figure 1: Energy imports in Indonesia, as percent from total energy use



Same as the rest of the world, considering the environmental protection concerns and limited energy resources, Indonesia is also pacing towards sustainable renewable energy development through its renewable energy potential such as Solar PV and geo thermal. According to the national energy plan 33% of the total capacity of power plant is targeted by 2025 according to national energy plan (RUEN). Moreover, along with the increasing degree of installed capacity, the level of electricity from renewable energy sources is targeted at 23% by the year 2025. The growing levels of environmental concerns and limited energy sources affects the energy growth patterns and its generation through renewable sources in Indonesia. The study has the following objectives:

1. Analyze the impact of innovation in increasing renewable energy in Indonesia
2. To determine the impact of research and development in increasing renewable energy in Indonesia.
3. Examine the impact of energy import in increasing renewable energy in Indonesia.

It is well known that the role on renewable energy plays an important role in a country. The consumption of renewable energy is not only important for economic and environmental benefits but it also compulsory for other useful benefits. For instance, renewable energy plays an important role in reducing greenhouse emissions. The basic purpose of this following paper is to analyze the energy consumption by the use of technology, innovation models and energy import. Based on the above analysis it is obvious that saving resources are important but it does not mean that our vision should be confined to it. The primary purpose of the given paper is to Ensuring Renewable Energy Consumption through Innovation, R&D and Energy Import in Indonesia. The results and findings illustrate there is a significant impact on the use of technology, innovation on energy consumption. At the

same time, the control variables have a significant impact on energy consumption. The higher is the population growth the higher is the energy consumption also (Purwanto, Sinaga, Hayati, & Sidik, 2021).

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