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Article

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Ensuring Renewable Energy Consumption through Innovation, R&D and Energy Import in Indonesia: A Time series Analysis

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ABSTRACT

Energy resources have now been scarce as the use of energy resources has been increased. There is a need to manage the resources as 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 variables 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 analysis is obtained by using Augmented Dickey Fuller (ADF), unit root tests, co-integration tests and Autoregressive distributed time lag (ARDL) models to understand the effect in chosen time period. The results indicate that innovation, research and development have a significant impact on renewable energy consumption. However, energy import has not been significantly impacting in the short run. 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.

Keywords: Renewable Energy Consumption, Innovation, Research and Development, Energy Import, ARDL, Indonesia
JEL Classifications: O13, B17

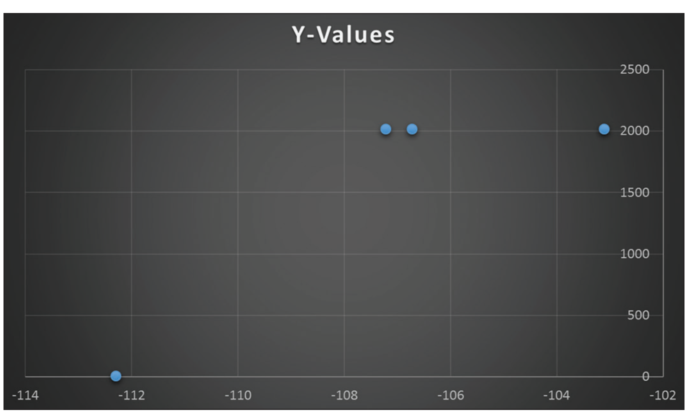
1. INTRODUCTION

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 are 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 (Gielen et al., 2019). 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 (Ali et al., 2017). Globally, the bulk of energy consumed is shifting from non-renewable energy, such as oil, gas and coal (Keho, 2016) to renewable energy sources such solar, hydropower, geothermal and biomass. 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 energy along with the high governmental funding due to the concern of protecting the environment boost the renewable energy growth and its market (Kelly-Richards et al., 2017; Mansoor and Sultana, 2018). 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 processes and determines the total production output and supply patterns of the country. The contribution of energy in growth of the economy is highlighted in the literature as the activities associated with economic growth determines the energy consumption patterns (Ozturk and Ozturk, 2018; Yang and Shi, 2017). Negative values in Figure 1 are showing Energy imports in Indonesia, as percent from total energy use.

Energy imports in Indonesia, as percent from total energy use is given in Figure 1. 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 (Alhamid et al., 2016). The increasing installed capacity for renewables in Indonesia is shown in Figure 1. 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 (Sugiawan and Managi, 2016). The growing levels of environmental concerns and limited energy sources affects the energy growth patterns and its generation through renewable sources in Indonesia (Ahmar, 2018). However, the earlier studies have examined several factors that affect the energy growth in general with the focus on multiple countries (Bhattacharya et al., 2016; Owusu and Asumadu-Sarkodie, 2016; Qureshi et al., 2016). Also, the renewable and non-energy consumption was studied simultaneously. But the scarcity of findings and studies was evidenced that are focused in determining the role of innovation, Research and development and energy import in Indonesia specifically. Thus, by recognizing the high levels of environmental concerns and technological diffusion in energy generation and growth across the globe to achieve sustainable energy goals and their effects on the environment and consumption patterns, the present study contributed to the fulfillment of research gap and aimed towards the investigation of renewable energy growth factors in Indonesia, and proposed the following research objectives:

1. To 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. To examine the impact of energy import in increasing renewable energy in Indonesia.

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



The findings of the study encompassed significant implications for energy regulations and policy makers that contributed towards the efficient energy policies considering the trends of innovation and environmental concerns. Moreover, the rest of the paper covered the relevant literature and formulation of hypotheses, in section 3 the methodology of the study is discussed, whereas in section 4 data analysis and results are discussed while section 5 includes a conclusion and future policy implications.

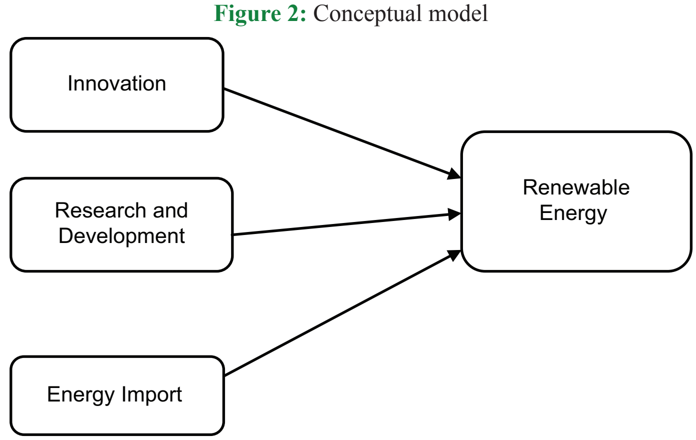
2. LITERATURE REVIEW

Throughout the energy growth literature, the key sources of energy growth are integration of innovative energy producing technologies, governmental policies to boost the renewable energy generation, and orientation towards sustainable energy growth and environmental protection (Afonso et al., 2017; Jebli and Youssef, 2015; Qureshi et al., 2016). Therefore in view of the increasing innovation diffusion, high scale Research and Development and trends in reduction of non-renewable energy import, the study incorporated innovation, Research and development and Energy import in Indonesia as the key drives of increasing renewable energy as shown in Figure 2. The reviewed literature is discussed as follows:

2.1. Innovation and Renewable Energy

Renewable energy comprised of the natural sources that can be replenished such as solar, wind, geothermal, hydropower and biomass. The drivers of renewable energy growth gained a huge attention in the literature (Twidell and Weir, 2015). Various studies have explored the relationship between energy consumption and the innovation level. Among the major factors, innovation is one key factors in driving energy consumption around the globe (Alvarez-Herranz et al., 2017). The nexus of technological innovation and renewable energy demand has been studied by Alvarez-Herranz et al. (2017) in Nordic countries, the results suggested that a unidirectional causality has been observed from innovation to consumption of renewable energy and an effective role is played by technological innovation in the growth of energy. Similarly, Kuzemko et al. (2017), Studied the

Figure 2: Conceptual model



nexus between renewable innovation and growth of energy in Germany, the outcomes indicated that a prominent role of demand side innovations in energy transformations and efficiency of renewable energy sector, transportation and increasing industrial outputs. Also, it is observed that through innovation processes, the effective development of energy takes place. In addition, the energy transition and growth process is examined in Germany (Guidolin and Guseo, 2016) with the emphasis on innovating such wind energy and photovoltaic for the generation of electricity and it is indicated by the findings that integration of innovative measures resulted in enhanced energy growth. moreover, the competitive factor of Chinese renewable energy industry was examined by Groba and Cao (2015), the results concluded that solar PV and wind energy technology innovation are the success factors of energy growth and its high export levels. It is proposed by the findings of Noailly and Smeets (2015) that a leading role is played by adoption of innovation in the renewable energy generation, rising demands of energy was created due to high industrial growth with the production that are energy intensive and the utilization of innovative methods results in efficient growth mechanism. In the same way, the effect of innovation processes on renewable energy generation was determined and the results postulated innovation-oriented energy generation polices enforced by the government and the diffusing of innovative technologies showed a major contribution in increasing the renewable energy and strongly affects efficient generation of technology (Tokimatsu et al., 2016) Thus, based on the reviewed literature and the observation of the strong link between industrialization and non-renewable energy consumption, the current study hypothesized that:

H_1: Innovation has a significant impact on renewable energy.

2.2. Research and Development and Renewable Energy

An essential role is played by research and development in the energy sector in the shifting from the non-renewable energy towards the renewable energy, as it is evidenced that the increase share of investment in the renewable energy research sector resulted in growth and sustainability and leads towards the process of transformation of energy generation structure, where the replacement of limited resources takes place with the sustainable energy sources (Zafar et al., 2019). Globally, the literature has been focused on the factors affecting rising trends of renewable energy generation as it is considered the essential source of sustainable economic development and environmental protection. It is suggested that with the utilization of full potential of renewable energy through extensive research, results in the generation of large portion electricity through renewables and also the Carbon emissions will be reduced by 81% and 88% in Indonesia and Thailand respectively (Zafar et al., 2019). Across the globe, a plethora of studies have examined the link between investments in research and development and renewable energy generation urbanization and its influence on the energy growth patterns in developed and developing countries (Kim et al., 2017; Putrasari et al., 2016). Such as the significance of renewable energy for developed and developing countries was emphasized by Hua et al. (2016) through the examination of commitment level of countries towards sustainable energy and concludes that the government funding of research, structural support are the influencing factors in increasing the growth of renewables. The channel demonstrated by the author is the increase in research and development generated through governmental support and initiatives created an significant and positive impact on the growth of renewable energy as it required the extensive amount of research to explore innovative energy generation methods (Grando et al., 2017). Therefore, in view of the discussed findings emphasized on the significant association of research and development in increasing renewable energy, the current study hypothesized that:

H_2: Research and development has a significant impact on renewable energy.

2.3. Energy Import and Renewable Energy

The generation of energy is replaced from non-renewable energy, such as oil, gas and coal by renewable energy sources. The rising trends of advanced technology resulted in generation of renewable energy along with the effective governmental policies due to the concern of protecting the environment boost the renewable energy growth and its market (Scholten and Bosman, 2016). The role of energy imports in enhancing renewable energy consumption was studied in multiple countries across US states and EU countries during the period of 1990-2008, it was found that a significant and positive influence is created by effective renewable import energy policies such as tax incentives, feed in tariffs and tenders in the encouragement of renewable sources (Kilinc-Ata, 2016). In the same way, the energy consumption patterns and success factors for renewable energy was studied by (Bölük and Mert, 2015; Kamran, 2018; Lucas et al., 2016) as sustainability in the energy sector heads towards sustainable economic growth, the results suggested that the dominance of imported non-renewable energy in developing countries resulted in costly energy generation, while the shift towards import of innovative methods for renewable energy generation such as solar PV technologies, innovative and efficient methods for generating wind power and hydropower leads towards the growth of renewable energy and its sustainability (Štreimikienė et al., 2016). Therefore, in view of the discussed findings emphasized on the significant association between energy import and increasing renewable energy, the current study hypothesized that:

H_3: Energy Import has a significant impact on Renewable energy.

3. METHODOLOGY OF THE STUDY

3.1. Data

The present research includes the data for Energy consumption (EC), Innovation (IN), R&D (RD), Energy import (EI), Population growth (PG) and Renewable energy consumption (REC). EC measured in kWh. The data for all of these variables is taken from the data of the past 25 years extending from a time period of 1995 to 2019 from Indonesia. This time span was accurately sufficient to use the A.R.D.L approach to conduct the analysis on the time series type of data and research. The data of past 25 years was collected from the data base of World Bank and related websites as well.

3.2. Model Specification and Econometric Methodology

3.2.1. Model

The aim of this study is to study the relationship between REC and IN, RD, EI, EC, PG. According to the study of (Lin and Liu, 2016), The resources are at a verge of their immense shortage which makes important to promote a sense of recycling and renew and reuse the renewable resources so that energy consumption can be maximized. Renewable energy resources can be renewed and reused involving some techniques in which innovation plays a fair role, research and development is a necessary in order to dig out new and innovative ways to use the renewable energy resources again and again in a beneficial way so that instead of energy import the existing resources can be used in a beneficial way to fulfill the growing energy needs with the population growth. In advocacy of the above-mentioned variables and their relationships and impact on each other, (Wang and Prominski, 2015) proposed a model to study these which is given below:

$$REC_t = \beta_0 + \beta_1 EC_t + \beta_2 EI_t + \beta_3 PG_t + \beta_4 RD_t + \beta_5 IN_t + \varepsilon_t \quad (1)$$

In the equation above, β_0 is the constant term, EC_t represents energy consumption measured in kWh, EI_t representing the energy import, REC_t represents the renewable energy consumption, RD_t represents the Research and development, IN_t represents the innovation, PG_t represents the population growth and at last ε_t is the measure of error. For the reduction of the potential heteroscedasticity, all of the variables present in the equation 1 are to be converted in the natural logarithms. For a conversion to the per capita form from the series form, series have been divided using population series. The converted logarithm form of the model is given as:

$$lnREC_t = \beta_0 + \beta_1 lnEI_t + \beta_2 lnEC_t + \beta_3 lnPG_t + \beta_4 lnIN_t + \beta_5 lnRD_t + \varepsilon_t \quad (2)$$

In the above equation 2, β_0 is a constant factor, β_i (in which i = 1, 2, 3, 4, 5) are the values of elasticity for the *EI*, *EC*, *PG*, *IN* and *RD* in the long term. The equation 1 was converted to equation 2 in order to monitor the long term relationships that could possibly exist between $lnREC_t$ (Natural log of renewable energy consumption in kWh) and $lnEC_t$ (Natural log of the energy consumption), $lnEI_t$ (Natural log of energy import), $lnPG_t$ (Natural log of the population growth), $lnIN_t$ (Natural log of innovation), $lnRD_t$ (Natural log research and development). The expected signs for β_1, β_2, β_3, β_4 and β_5 are positive.

3.2.2. Estimation model

3.2.2.1. Unit root

For the analysis of the stationarity of the present data the unit root test will be used, this test is also used in order to check that whether or not the presented model is feasible for the study under conduct. Another difficulty is to select the right test for the model as well. In the study under conduct, "Augmented Dickey Fuller test (1981), Philips-Perron (P.P.) test (1988), Kwiatkowski Philips-Schmidt-Shin (K.P.S.S.) unit root test" are used, which will make sure of the integration of the series and will also provide confirmation for the presence of the unit roots in the variables selected.

3.2.2.2. Bounds test of co-integration

The study implements the "Pesaran et al. (2001) A.R.D.L. bounds test" on the series which has been confirmed of its integration, this application is now done for confirmation of co-integration. This test of co-integration is flexible as compared to other ones. The ARDL model is used in order to study long term relationships of the variables and it is done so by an optimal lag length. The identification of dependent and independent variables can be done in ARDL model "Wald test of joint significance or F-test" is used determine long term relationships in equation 3:

$$\begin{aligned}\Delta \mathrm{lnREC_t} = \beta_0 + \sum_{i=0}^{P} \beta i \Delta \mathrm{lnREC_{t-i}} + \sum_{j=0}^{q} \beta j \Delta \mathrm{lnEC_{t-j}} + \\ \sum_{k=0}^{r} \beta k \Delta \mathrm{lnEI_{t-k}} + \sum_{i=0}^{s} \beta l + \Delta \mathrm{lnIN_{t-1}} + \\ \sum_{m=0}^{t} \beta m \Delta \mathrm{lnRD_{t-m}} + \sum_{n=0}^{u} \beta n \Delta \mathrm{lnPG_{t-n}} + \\ \lambda_{REC} \mathrm{lnREC_{t-1}} + \lambda_{EC} \mathrm{lnEC_{t-1}} + \lambda_{EI} \mathrm{lnEI_{t-1}} + \\ \lambda_{IN} \mathrm{lnIN_{t-1}} + \lambda_{RD} \mathrm{lnRD_{t-1}} + \lambda_{PG} \mathrm{lnPG_{t-1}} + \upsilon_t\end{aligned} \quad (3)$$

Here, the error factor is represented by υ_t, Δ is there to represent the short term, as Wald test is also used for more than 1 variables in the short term, co-efficient of all of the differenced variables in short term are equal to 0. There are 2 bounds, the upper and lower one, if value of estimated F-statistic is more than upper bound null hypothesis is rejected and it is not rejected if it is beneath that value. After this estimation of co-integration, the estimation of long term and short-term elasticity can be studied as under in equation 4 and 5:

$$\begin{aligned}\mathrm{lnREC_t} = \alpha_1 + \sum_{i=1}^{P} \varphi 1_i \mathrm{lnREC_{t-i}} + \sum_{j=1}^{q} \omega 1_j \mathrm{lnEC_{t-j}} + \\ \sum_{k=1}^{r} \O 1_k \mathrm{lnEI_{t-k}} + \sum_{l=1}^{s} \partial 1_l \mathrm{lnIN_{t-1}} + \\ \sum_{m=1}^{t} \upsilon 1_m \mathrm{lnRD_{t-m}} + \sum_{n=1}^{u} 1_n \mathrm{lnPG_{t-n}} + \mu_t\end{aligned} \quad (4)$$

$$\begin{aligned}\mathrm{ln\Delta REC_t} = \gamma_0 + \sum_{i=1}^{P} \gamma 1_i \mathrm{lnREC_{t-i}} + \sum_{j=1}^{q} \gamma 1_j \mathrm{lnEC_{t-j}} + \\ \sum_{k=1}^{r} \gamma 1_k \mathrm{lnEI_{t-k}} + \sum_{l=1}^{s} \gamma 1_l \mathrm{lnIN_{t-1}} + \\ \sum_{m=1}^{t} \gamma 1_m \mathrm{lnRD_{t-m}} + \sum_{n=1}^{u} \gamma 1_n \mathrm{lnPG_{t-n}} + \psi \mathrm{ECT_{t-1}} + \mu_t\end{aligned} \quad (5)$$

In equation 5, the ECT_{t-1} is the error correction term, moreover, it must be negative and value of coefficient should be between 0 and 1. From the 2 equations above long term and short-term elasticity can be studied.

3.3. Model Stability and Diagnostic Tests

The diagnostic tests are used to identify heteroscedasticity, residual serial correlation and correlogram of residuals. Test of cumulative sum C.U.S.U.M is used for stability test of coefficients for the long-term. In this, Granger causality test is used for testing the causality direction for the estimated variables.After confirmation of long-term relation through equation 2, the error correlation model is developed as in equation 6 below:

$$\begin{bmatrix} \Delta lnREC \\ \Delta lnEC \\ \Delta lnEI \\ \Delta lnIN \\ \Delta lnRD \\ \Delta lnPG \end{bmatrix} = \begin{bmatrix} a1 \\ a2 \\ a3 \\ a4 \\ a5 \\ a6 \end{bmatrix} + \begin{bmatrix} S11,1 & S12,1 & S13,1 & S14,1 \\ S21,1 & S22,1 & S23,1 & S24,1 \\ S31,1 & S32,1 & S33,1 & S34,1 \\ S41,1 & S42,1 & S43,1 & S44,1 \\ S51,1 & S52,1 & S53,1 & S54,1 \\ S61,1 & S62,1 & S63,1 & S64,1 \end{bmatrix} \times$$

$$\begin{bmatrix} \Delta lnRECt-1 \\ \Delta lnECt-1 \\ \Delta lnEIt-1 \\ \Delta lnINt-1 \\ \Delta lnRDt-1 \\ \Delta lnPGt-1 \end{bmatrix} + \begin{bmatrix} S11,1 & S12,1 & S13,1 & S14,1 \\ S21,1 & S22,1 & S23,1 & S24,1 \\ S31,1 & S32,1 & S33,1 & S34,1 \\ S41,1 & S42,1 & S43,1 & S44,1 \\ S51,1 & S52,1 & S53,1 & S54,1 \\ S61,1 & S62,1 & S63,1 & S64,1 \end{bmatrix} \times$$

$$\begin{bmatrix} \Delta lnRECt-m \\ \Delta lnECt-m \\ \Delta lnEIt-m \\ \Delta lnINt-m \\ \Delta lnRDt-m \\ \Delta lnPGt-m \end{bmatrix} + \begin{bmatrix} \varphi 1 \\ \varphi 2 \\ \varphi 3 \\ \varphi 4 \\ \varphi 5 \\ \varphi 6 \end{bmatrix} \times \left(\mathrm{ECT}_{t-1}\right) + \begin{bmatrix} \eta 1t \\ \eta 2t \\ \eta 3t \\ \eta 4t \\ \eta 5t \\ \eta 6t \end{bmatrix} \quad (6)$$

In equation 6 Δ represents first difference operator and ECT_{t-1} represents the lagged error correction term which must be between 0 and 1 with a negative sign. Equation 2 gives a confirmation of short-term relationship and VECM model confirms long term relationship among variables. F-statistic will be used for knowing about weak or short-term Granger causality.

4. EMPIRICAL ANALYSIS

The unit root tests are directed to understand how the effects of the variables have transformed over the years or they have not altered. As the research is covered on the data attained over a period of 25 years, we have to make sure that the variable we are calculating applies the same results usually as it did in the past years. Further, LLC unit root test is also conducted. Both the ADF and LLC are measured at level and at the first differences along with the check of intercept. The null hypothesis of this test states that there is unit root in the variables and that these are non-stationary. The results are described as Table 1:

4.1. ADF and LLC Unit Root

Looking at the results of ADF test, we can see that at level, innovation, research and development, energy consumption and renewable energy consumption have been significant hence rejecting the null hypothesis of non-stationarity. Therefore, these variables have been stationary over the time. Nevertheless, all the construct has been observed to be significant at the 1st difference I the ADF test and shown significance at 5% level, thereby rejecting the null hypothesis of non-stationarity. Therefore, the variables have been stationary at the 1st difference intercept.

The results of LLC test at level state that innovation, energy import, and energy consumption have been significant hence rejecting the null hypothesis of non-stationarity. Therefore, these variables have been stationary over the time. At the first differences, all the constructs had been significant at 5% and 10 % level of significance, thereby rejecting the null hypothesis of non-stationarity. Therefore, the variables have been stationary at the 1st difference intercept.

4.2. Co-integration Test Results

The co-integration test is conducted to see the altogether relation of the constructs among each other, as whether these are integrated with each other in the long run or not and it also accounts for the theoretical relationship of the constructs. Here we use the OPL (A.I.C.) to see the implication of the constructs as determined by the F-significance test. The F-value should be above the upper and lower bound critical values so we can reject the null hypothesis which states that the co-integration does not exist among the variables (Table 2). The results are as follows:

The F-statistic value is 14.3 which is highly significant at 10% level of significance which specifies that we discard the null hypothesis that all slope coefficients equals zero. Also, the lower and upper bound critical value of the co-integration lie below the bound test which further implies the presence of co-integration among the variables. The consequences also contribute in the direction of the testing of A.R.D.L. model for this study.

4.3. ARDL Estimation Results

The Autoregressive time lag method is used to see the effect of change on the renewable energy consumption through energy import, research and development, and innovation. The results below show the ARDL technique short run and long run estimation results (Table 3).

The long run results explain that innovation, research and development, and energy consumption have been significant at 5% level. Also, the energy import and population growth have been significant at 10% and 1% level respectively. The analysis explains that innovation has an effect of 34% on the renewable energy consumption. The research and development have an impact of 29% and energy import has the highest impact of 39% on the renewable energy consumption. The control variables have also had significant

Table 1: ADF and LLC unit root

Constructs	ADF test		LLC test	
	Level	1st diff.	Level	1st diff.
IN	1.394*	5.394**	−1.485*	−5.469**
RD	0.398	5.848**	−0.596	−6.496***
EI	1.395*	7.596**	−5.498*	−5.707***
EC	0.305*	6.506**	−4.496*	−8.597***
PG	2.493	5.495**	−0.507	−4.596***
REC	4.884*	7.593**	−1.653	−9.439***

Table 2: Co-integration test

O.P.L. length (A.I.C)	(3,0,0,1,0,0)		
F-Stat. (Bound test)	14.348***		
V.C	1%	5%	10%
L.B.C.V.	2.47	1.97	1.46
U.B.C.V.	4.44	3.96	3.24

Table 3: ARDL estimation results

Run long results	B	t-value	Summary and diagnostic test	
REC	1.287***	-	R^2	0.678
REC (−1)	0.478**	-	Adj. R^2	0.637
REC (−2)	0.387***	-	DW	2.03
IN	0.183	3.457**	X^2SC	1.867 (0.998)
RD	0.128	2.986**	X^2W	2.890 (0.890)
EI	0.301	3.987***	X^2AR	2.876 (0.343)
EC	0.231	2.876**		
PG	0.203	2.865*		
C	2.141	2.685**		
Short run results	**B**	**t-value**	**Summary and diagnostic test**	
IN	0.133	3.353***	R^2	0.658
RD	0.197	2.465**	Adj. R^2	0.634
EI	0.053	1.354	X^2SC	1.434 (0.865)
EC	0.234	2.854**	X^2W	2.465 (0.354)
PG	0.076	1.464	X^2AR	0.865 (0.243)

impact on the renewable energy consumption. The adjusted R square value explains that all the variables have a combined effect of about 63% on the renewable energy consumption.

The short run results differ slightly from the long run results. Here innovation ha a significant impact of about 33% effect on the renewable energy consumption, research and development make an increase of about 24%, and energy consumption make an effect of about 28% on the renewable energy consumption. However, population growth and energy imports had insignificant effects on the renewable energy consumption. This implies that if the people focus more on innovation, research and development and start to import the energy resources then they can ensure the renewable energy consumption in Indonesia.

5. DISCUSSION AND CONCLUSION

5.1. Discussion

This is well known that the role of 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 gas emissions (Martire et al., 2018). The basic purpose of this following paper is to analyze the energy consumption by the use of technology, innovation models and energy import. At the same time, energy consumption as well as population growth act as control variables.

The results and findings of the study evaluate that the role of innovation in energy consumption is highly essential. The role of innovation and investment in R and D is essential because this is the era of technology. Almost each sector use technology, innovation in order to enhance efficiency (Otto and Wittenberg, 2018). Different previous studies also examined the relationship of technology as well as energy consumption. Many scholars believe that technological innovation can improve energy efficiency and thereby lead to a reduction in energy consumption whether it is for the total energy consumption of fossil fuel (Favre et al., 2018). Meanwhile, some scholars believe that energy consumption will not be limited when the resources stock is rich, and people will not consider the issue of technological innovation. Or when the energy supply is sufficient and its application is more and more mature, people will not consider using technological innovation to increase the supply of energy. Another research examined the role of innovation and technology on energy consumption in both the long and short-run as a positive.

The results and tables indicate significant results. The ARDL table indicates the significant value to prove the significant impact of technology on energy consumption. Moreover, the firms and countries who majorly invest in research and development, it accelerates the progress and vice versa. At the same time, technological innovation has played an important enabling role in the early phases of the world's energy transition.

The population growth and energy consumption and population growth act as control variables. The control variables significantly affect renewable energy. It is illustrated that the population growth affects energy consumption (Ibrahiem, 2018). The higher is the population growth, the more will be the energy consumption. Therefore, energy consumption directly links to energy consumption.

5.2. Implications

Renewable energy consumption through innovation and technology affect energy usage in Indonesia. The results and tables explained that there is a significant relation to the use of technology and innovation affect the energy consumption process in Indonesia.

5.3. Limitations

The empirical study provides several new insights into the relationship. In the short run, technological innovation positively affects energy consumption growth, as well as in, long run the use of technology affects energy consumption. However, the study mainly highlights the importance of energy consumption and technology. It is recommended that future studies focus on other variables such as the use of technology and energy production, the use of technology and the energy-efficient rate.

5.4. Conclusion

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 time series analysis has been done in this study. Moreover, the ARDL estimation approach has been applied. The results and findings illustrate that 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.

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