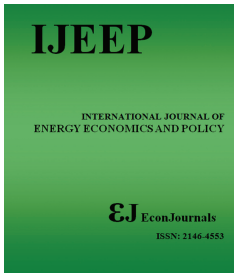

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The Role of Renewable, Non-renewable Electricity Consumption and Carbon Emission in Development in Indonesia: Evidence from Distributed Lag Tests

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ABSTRACT

The current examination aims to explore the critical relationship of energy, in the form of electricity with economic growth of Indonesia. Contrary to traditional approach of assessing the impact of energy consumption, the present study analyzes the association from production point of view by assessing the impact of electricity production on economic development. In doing so, the current study has adopted the refined methodology of auto-regressive distributed lags (ARDL) bound testing approach to examine the dynamic relationship among renewable (RE) electricity generation, non-renewable (NRE) electricity generation and economic growth with amplified understanding of the critical association to support the course of economic planning and policy making. The results of ARDL bound testing approach confirm that RE electricity generation, NRE electricity generation and carbon dioxide emission are solid determinants of economic development in Indonesia. Moreover, the results avow that RE electricity and NRE electricity generation have a useful and beneficial outcome on economic development in Indonesia.

Keywords: Renewable Electricity Generation, Nonrenewable Electricity Generation, Carbon Dioxide Emission, Indonesia
JEL Classifications: Q42, Q43

1. INTRODUCTION

Regardless the rising apprehensions for environmental degradation, the extensive usage of energy has been witnessed as the crucial stimuli of country's economic progress (Bento and Moutinho, 2016). The emergence of industrial revolution in early 1880 s fetched the significance of utilizing several forms of energies to boost economic activities especially in manufacturing and transportation industries (Bayraktutan, et al., 2011). The eminent role of energy in influencing income levels have also been identified in many earlier theoretical views. According to neo-classical belief, energy is the major intermediary of country's economy (Heidari et al., 2013). On the other hand, the ecological view assert energy to be the primary and fundamental factor that affect development (Ockwell, 2008).

The evolution of industries and contemporary economies utilizing technological advancements heavily relied on smooth production process. In this regard, electricity consumption and generation are both critical in altering economic success for not only being utilized as the prime input but also for influencing country's trade. Many studies argue that suitable and consistent energy supply is considered as an imperative pillar of industrial development and economic advancements of both developed and under developed nations (Morimoto and Hope, 2004; Ferguson et al., 2000; De Franchi and Boubaker, 2014; Behera, 2015; Ibrahim-Shwilima, 2016 Hwang and Yoo, 2014). Hence, the vitality of energy is seen imperative to capture future growth, however, the negative consequences of energy are parallelly criticized for enhancing ecological pressure and abruption sustainable development.

The current environmental condition carries numerous threats to mankind's future survival. Increasing levels of global warming and deteriorating ecological condition are the reasons behind increasing global concerns for sustainability. The harmful fossil fuel emanation resulted from extensive utilization of non-renewable (NRE) energy is the prime cause of augmenting air pollution (Olanrele, 2018; Ozturk and Ozturk, 2018). Keeping in mind the inevitable role of energy in influencing economic development, decoupling hazardous emissions in the form of green-house gases from country's economic progress have become an important sustainable objective (Bento and Moutinho, 2016; Arisanty et al., 2017; Momoh et al., 2018).

In this regard, business and economies, all around the world, are keen to adapt eco-friendly methods to ensure sustainable development through environmental safety and improvement. This lead to upsurge the utilization of NRE sources of energy that are debated for bringing ecological betterments by causing no or minimal damage to atmosphere. More recently, the inspirations for utilizing renewable (RE) sources of energy for electricity consumption have been regarded as the prime goal of sustainable advancements (Meza et al., 2019). The production of electricity from NRE sources have been motivated to reduce the energy dependence of the countries from harmful energy sources.

Indonesia has copious ability of producing power from numerous sources. The country is among the greatest worldwide exporter of coal & has colossal reserves of oil (Dutu, 2016), therefore extensively relies upon such sources to generate electricity and foster trade. However, the productivity of Indonesia's energy industry has progressively demonstrating the declining pattern from its 2010 benchmark, instigating the potential declining inclination in export shares (IEA, 2015). Such negative trend is attributed from several unrealistic domestic barriers to improve production without subsidizing cost and insufficient investments to appeal local and international collaborations (Dutu, 2016). In addition, the unbalanced emphasis on RE and NRE sources of energy accumulation is also one of the crucial causes of Indonesian declining industry outputs. These conditions pose enormous threats to stability of energy supplies and industrial output and likely to hinder growth process.

Therefore, the current examination aims to explore the critical relationship of energy, in the form of electricity with economic growth of Indonesia. Contrary to traditional approach of assessing the impact of energy consumption, the present study analyzes the association from production point of view by assessing the impact of electricity production on economic development. In doing so, the existing study does not merely rely on aggregate electricity production but investigated the individual separate impact of RE and NRE electricity generation on economic growth of Indonesia. Witnessing the decline in energy output in Indonesian industries, the investigations on how important the two forms of power production are in stimulating country's progress is vital to plan future policies and offering governmental support to associated industries.

In addition, several investigations in past have analyzed the role of energy consumption on output development, but the horizon of those studies were more towards carrying out panel assessments (Alam et al., 2017; Mahadevan and Asafu-Adjaye, 2007; Apergis and Payne, 2010). Although panel investigations are beneficial in Even though panel investigations are fruitful in attaining the overall comprehensive accord, but, unsuccessful in recognizing precise and detailed inference ascended from time-series. Also, few studies that carried time-series examinations in assessing energy-growth dynamics are restricted to basic approaches & empirical investigations (Brunnschweiler, 2008; Chi et al., 2009; Shah and Rivera, 2007), thus, lack in terms of reliable outcomes (Katircioglu, 2009). In response, the present study after acknowledging the significance of energy supply in Indonesian economy is determined to evaluate the relationship and electricity, generating from both RE & NRE sources, with Indonesian output growth through modelling the advanced methodology of auto-regressive distributed lags (ARDL) bound testing that is acknowledged as the reliable method of reaching authentic outcomes and impartial conclusions (Katircioglu, 2009).

The remaining of the examination is outlined as below. Section two will present the review of prevailing literature on the energy-growth nexus in general and RE and NRE electricity generation in particular. Furthermore, section three will demonstrate the utilized methodology for the current investigation. Moreover, section four will display and interpret the empirical results and finally, section five will summarize the investigation with conclusion and recommendations.

2. LITERATURE REVIEW

Many studies identified the critical relationship of energy utilization with economic development (Ali and Haseeb, 2019; Haseeb et al., 2018; Suryanto et al., 2018). Among them, the sphere of earlier studies is focused towards identifying aggregate association of energy consumption and production with country's growth process. However, from last decade, the focus of majority of the studies is diverted in recognizing specific connection of numerous forms of energies with output growth (Alam et al., 2017; Bilgili and Ozturk, 2015; Apergis and Payne, 2011; Lotfalipour et al., 2010) among them.

In a panel estimation, Destek (2016) studied the association of natural gas energy consumption and output growth of twenty six OECD economies. In doing so, the authors utilized data from the period of 1991 to 2013. In order to perform statistical investigation, the authors applied the empirical techniques of DOLS and FMOLS for identifying long term associations along with VECM to investigate causal connections. The outcomes of long run association revealed that natural gas has a significant positive connection with economic development of the sampled countries. Furthermore, the results of causal investigations suggested that there exist a uni-directional causal association between natural gas and output development in short-run, however, the study confirmed the presence of the bi-directional causal relationship between the variables in long-run for OECD nations.

On the other hand, Bento and Moutinho (2015) inspected the relationship between RE and NRE electricity production and in

Italy. For this, the study used the data from the time-period of 1960 to 2011. The empirical findings for the causal investigation indicated that there exist a uni-directional causal association between economic development and RE electricity production where the direction of causality run from GDP to RE electricity of the country confirming growth effect. In addition, the results also reported the presence of uni-directional causal connection from NRE electricity to RE electricity indicating the presence of conservation effect in Italy.

For a panel of OECD nations, Ohler and Fetters (2014) investigated the connection between RE electricity production and output growth in twenty OECD economies. In doing so, the authors used the data from the period of 1990 to 2008. The findings from panel ECM reported that RE sources of electricity production namely biomass, waste, hydroelectricity and wind power are significant to effect output growth in the sampled nations highlighting that rise in RE electricity generation enhances economic development. Moreover, the results for causal investigations reported the presence of feedback effect among economic growth and aggregate RE power.

Similarly, Apergis and Payne (2012) examined the association of RE and NRE electricity utilization with output growth in a mixed panel of eighty economies. In doing so, the study consumed the data from the time period of 1990 to 2007. Applying the technique of heterogeneous panel cointegration, the outcomes of the study reported the significant long-run association among RE, NRE and growth. In particular, the results identified the positive impact of independent variables on output growth. In addition, the study also tested the causal relationship between energy-growth nexus. The results from panel ECM, similar to Ohler and Fetters (2014), suggested the presence of feedback causal association among RE and NRE energy with GDP of the sampled countries.

In another panel study, Ciarreta and Zarraga (2010) evaluated the causal association between electricity generation and output growth of twelve EU nations. For this, the authors utilized the annual time series from the period of 1970 to 2007. Modeling the panel causality and VECM, the study recognized the significant long-run association between power utilization and output. In particular, the results confirmed that increase in energy utilization tends to decrease output growth. Furthermore, the findings of causal investigations, similar to Apergis and Payne (2012), reported the presence of feedback association between energy-growth nexus.

In Indonesia, Yoo and Kim (2006) examined the association of energy utilization with output development between the years 1971 and 2002. In order to perform empirical inspection, the authors applied J-J cointegration and granger causality tests. The results from J-J cointegration failed to confirm the presence of significant association between energy and Indonesian GDP. However, unlike Ciarreta and Zarraga (2010) and Ohler and Fetters (2014) and similar to Bento and Moutinho (2016), the findings of causal investigation reported the presence of uni-directional causal connection with the evidence of growth effect.

In another study of OECD member nations, Bayraktutan et al., (2011) examined the association of RE power production and output development. Using the mixed sample of thirty OECD economies from 1980 to 2007, the outcomes of the study identified the significant association of RE power production and output growth of the sampled countries. In addition, the results suggested that increase in RE sources of power production have the tendency to augment country's economic growth. As for the causal investigation, the authors of the study reported the feedback association between RE power production and output growth of the sampled countries.

3. METHODOLOGY

In the current study, we examine the energetic connection between electricity generation from (RE and NRE sources) and economic growth and the empirical framework is a s follows:

$$Y=\beta_0+\beta_1\,(NEG)+\beta_2(REG)+\beta_3\,(CO_2)++\varepsilon_t$$

Where, ε_t is the error term, *NEG* denotes the electricity generation from the *NRE* sources which is calculated by the total energy generation excluding from RE sources and measured as per capita of metric tons of oil equivalent, *REG* is the electricity generation from RE sources also measured as per capita of metric tons of oil equivalent, CO_2 is the carbon dioxide emission which is measured as per capita of metric kilo tons. The data for the present investigation is collected from the time frame of 1981 to 2017. All the data are collected from World Development Indicators (World Bank).

3.1. Unit Root Tests

After the descriptive statistics, we apply unit root test to check the stationarity property of the focus time series data as applied in earlier crucial studies (Chandio, et al., 2016; Taib et al., 2018). In doing so, the current study applies two renown unit root approaches that are Augmented-Dickey Fuller (ADF) and Philip-Perron (PP) unit root tests. For confirming the stationarity property, we first examine the data on level series and then of first difference series.

3.2. ARDL Bound Testing Cointegration Analysis

For investigating the influence of RE electricity generation and NRE electricity generation on economic growth in Indonesia, we study the ARDL methodology of long-term linkages which was introduced by Pesaran et al. (2001, 2000), Pesaran et al. (1999), Pesaran and Pesaran (1997). The ARDL methodology is applied with the help of unhindered vector error correction system to investigate the long-run relationship between RE electric generation, NRE electricity generation and economic growth in Indonesia. This methodology has a few advantages on previous long-term association investigations (like J.J cointegration and simple correlation). This methodology might be useful whether the focus time series data are totally I(0), I(1) or similarly co-incorporated (Bento and Moutinho, 2016; Hussain et al., 2019; Saudi et al., 2019a). The ARDL structure is suggested for above investigation is given below:

$$\Delta Y = \varphi_0 + \varphi_1 \sum_{i=1}^{p} Y_{t-1} + \varphi_2 \sum_{i=1}^{p} REG_{t-1} + \varphi_3 \sum_{i=1}^{p} NEG_{t-1} + \varphi_4 \sum_{i=1}^{p} CO2_{t-1} + \gamma_1 Y_{t-1} + \gamma_2 REG_{t-1} + \gamma_3 NEG_{t-1} + \gamma_4 CO2_{t-1} + \mu_t$$

where, φ_0 is consistent term and μ_t is background noise period, the error correction limit is explained to by the indication of summation though the other proportion of the equation identifies with long-run association. The Schwarz Bayesian Criteria (SBC) is used to look at the greatest lag length choice for every factor (Sinaga et al., 2019a). In ARDL technique, at first the present investigation ascertains the F-stats importance by applying the appropriate ARDL systems (Saudi et al., 2019b). Then, the Wald (F-stats) method is used to investigate the long-run relationship between the factors (Sinaga et al., 2019b). In the event that long-term relationship between *Y*, *REG*, *NEG* and CO_2 are estimated, at that point the present investigation determined the long-term parameter estimations by utilizing resulting framework.

$$Y_t = \zeta_0 + \zeta_1 \sum_{i=1}^{p} Y_{t-1} + \zeta_2 \sum_{i=1}^{p} REG_{t-1} + \zeta_3 \sum_{i=1}^{p} NEG_{t-1} + \zeta_4 \sum_{i=1}^{p} CO2_{t-1} + \mu_t$$

Initially, in the current study if the long-run association between *Y*, *REG*, *NEG* and CO_2 is established with sign then we estimate the beta coefficient of the short-run by focusing the below equation:

$$Y_t = \delta_0 + \delta_1 \sum_{i=1}^{p} Y_{t-1} + \delta_2 \sum_{i=1}^{p} \mathrm{REG}_{t-1} + \delta_3 \sum_{i=1}^{p} \mathrm{NEG}_{t-1} + \delta_4 \sum_{i=1}^{p} \mathrm{CO2}_{t-1} + \mathrm{nECT}_{t-1} + \mu_t$$

Finally, the error correction model demonstrate the speed of change permit to gauge the long-run equilibrium because of a short-run variation. The *n* is the estimation of ECT in the system that clarify the speed of change.

3.3. Variance Decomposition Method (VDM)

In this study, we further apply VDM to confirm the causal relationship between Y, REG, NEG and CO_2 in Indonesia. The VDM provides the size of the predicted error variation for an information accountable for originalities by each predictor upon different time frequency (Abdullah et al., 2018).

4. DATA ANALYSIS AND DISCUSSION

The present section clarifies about the data examination. Essentially, we used stationary test to certify the stationary property of the considered variables. The results of unit root test are represented in Table 1. We utilized two distinctive unit root tests to be explicit (ADF and PP) test to affirm the stationary properties of the variables. The results avow that Y, REG, NEG and CO_2 at first are not stationary at level and ends up stationary at first distinction series. Generally, the consequences of unit root test, we can conclude that series of number of variables demonstrate the stationary properties and allow for continuing to the long-run investigation.

In addition, to examine the long-term connection between Y, REG, NEG and CO_2 in Indonesia, the ongoing exploration utilized the novel methodology of ARDL. In doing as such, the underlying procedure is to indicate the most extreme lag length of overall factors chose for this investigation. The order of this maximum lag length is chosen by the standards of SBC as referenced before. In this way, the outcomes of the ARDL long run relationship results are shown in Table 2.

The results of Table 2 certify the Ho attesting that no cointegration among the variables is rejected. This is a result of the value of the F-stats is greater than UBC coefficient at 1% significance level. Thusly, it is in the support of acknowledgment of the H_1 which suggest that there is a substantial long-term connection exist between Y, REG, NEG and CO_2 emission in Indonesia.

The results of ARDL bound testing cointegration test, in this manner, set up the robustness of accomplished results.The results of selection of lag length is presented in Table 3. It is demonstrated that a solid long-run relationship shows between Y, REG, NEG and CO_2 in Indonesia. Likewise, in the wake of insisting the sign of long run relationship between the considered variables, the subsequent stage of the examination is to distinguish the ARDL framework with the purpose of finding the beta coefficient of long-short run time. For this reason, the present examination calculates the lag length order of all the considered factors by the minimum assessment of SBC.

The consequences of long run estimations are shown in Table 4. The outcomes thusly set up that RE electricity generation, NRE electricity generation and carbon dioxide emission are solid determinants of economic development in Indonesia. Moreover, the results avow that RE electricity and NRE electricity generation have a useful and beneficial outcome on economic development in Indonesia which infers that the electricity generation from any sources are the principle requirement of economic development in Indonesia over the long run. Moreover, the results of ARDL further suggested a negative effect of carbon dioxide emission on economic development in Indonesia. Likewise, it very well discussed that all variables including RE electricity generation, NRE electricity generation and carbon dioxide emission are essential supporter of edifying the economic development in Indonesia.

The results of short run beta of ARDL examination is exhibited in Table 5. The outcomes affirmed a significant short-run association between Y, REG, NEG and CO_2 emission in Indonesia. The proportion of error term is connoting near −0.335 suggest that practically 33.5% of shakiness is change in the ongoing year. In addition, the outcomes likewise propose the critical impact of RE

Table 1: Results of unit root test

Variables	ADF unit root test				PP unit root test			
	I (0)		I (1)		I (0)		I (1)	
	C	C&T	C	C&T	C	C&T	C	C&T
Y	1.302	1.340	−5.049	−5.055	1.144	1.171	−5.016	−4.323
REG	0.338	0.417	−4.074	−3.945	0.329	0.419	−4.350	−4.288
NEG	−0.209	−0.206	−4.322	−4.708	−0.197	−0.228	−4.593	−4.576
CO_2	−1.374	−1.271	−4.283	−4.339	−1.286	−1.265	−4.291	−4.319

The critical values for ADP and PP tests with constant (C) and with constant and trend (C and T) 1%, 5% and 10% level of significance are −3.711, −2.981, −2.629 and−4.394, −3.612 and -3.243 respectively. Source: Authors' Estimations, ADF: Augmented-dickey fuller, PP: Philip-Perron

Table 2: Results of bound testing for cointegration

Lags order	AIC	HQ	SBC	F-test statistics
0	−4.464	−5.031	−5.084	51.226*
1	−6.963*	−6.754*	−6.846*	
2	−5.402	−5.337	−5.408	
3	−5.395	−5.279	−5.683	

Source: Authors' estimation. *1% level of significant

Table 3: Results of lag length selection

Lag	0	1	2	Nominated lags
	SBC	SBC	SBC	SBC
CAP	1.512	−4.888*	−3.032	1
LBF	3.447	−3.794*	−2.729	1
NG	1.674	−5.535*	−4.901	1

*Indicate minimum SBC values, Source: Authors' estimation

Table 4: Results using ARDL approach (long run)

Variables	Coeff.	t-stats	Prob.
C	0.344	4.534	0.000
Y (−1)	0.171	9.060	0.000
REG	0.451	5.134	0.000
REG (−1)	0.032	5.411	0.000
NEG	0.448	6.907	0.000
NEG (−1)	0.174	4.467	0.000
CO_2	−0.457	−11.773	0.000
CO_2 (−1)	−0.312	−3.234	0.000
Adj. R^2	0.925		
D.W stats	2.116		
F-stats (Prob.)	2237.425 (0.000)		

Source: Authors' estimation, ARDL: Auto-regressive distributed lags

Table 5: Results using ARDL approach (short run)

Variables	Coeff.	t-stats	Prob.
C	0.264	5.508	0.000
Y (−1)	0.049	3.188	0.000
REG	0.279	8.655	0.000
REG (−1)	0.037	2.828	0.000
NEG	0.279	8.590	0.000
NEG (−1)	0.109	0.508	0.000
CO_2	0.276	11.188	0.000
CO_2 (−1)	0.195	3.092	0.000
ECM (1)	−0.335	−11.652	0.000
Adj. R^2	0.911		
D.W stats	1.992		
F-stats (Prob.)	1228.543 (0.000)		

Source: Authors' estimation, ECM: Error correction model, ARDL: Auto-regressive distributed lags

electricity generation, NRE electricity generation and carbon dioxide emission on economic growth in Indonesia in short run period too.

The results of Table 6 show the causal relationship among Y, REG, NEG and CO_2 in Indonesia. The outcomes of Y model define that in first stage, the variation in Y is pronounced 100% totally by its improvements. In the following level, 91.884% display by own improvements, 6.959% by RE energy generation, 0.352% by NRE energy generation and 0.805% by carbon dioxide emission. In 3rd year, period the changes in Y define 85.016 % by its own improvements, 12.836% by RE electricity generation, 0.438% by NRE electricity generation and 1.710% by carbon dioxide emission. In the 5th year, the variations in Y define 82.326% by its own enhancement, 12.824% by RE electricity generation, 2.732% by NRE electricity generation and 2.118% by carbon dioxide emission. The consequences of Table 6 further suggest the bi-directional causal connection among all considered variables, however, the magnitude of the causality is unique.

5. CONCLUSION AND RECOMMENDATION

The current environmental condition carries numerous threats to mankind's future survival. Increasing levels of global warming and deteriorating ecological condition are the reasons behind increasing global concerns for sustainability. The harmful fossil fuel emanation resulted from extensive utilization of NRE energy is the prime cause of augmenting air pollution. Keeping in mind the inevitable role of energy in influencing economic development, decoupling hazardous emissions in the form of green-house gases from country's economic progress have become an important sustainable objective.

In this regard, business and economies, all around the world, are keen to adapt eco-friendly methods to ensure sustainable development through environmental safety and improvement. This lead to upsurge the utilization of NRE sources of energy that are debated for bringing ecological betterments by causing no or minimal damage to atmosphere. More recently, the inspirations for utilizing RE sources of energy for electricity consumption have been regarded as the prime goal of sustainable advancements. The production of electricity from NRE sources have been motivated to reduce the energy dependence of the countries from harmful energy sources.

The current examination aims to explore the critical relationship of energy, in the form of electricity with economic growth of

Table 6: Results of variance decomposition approach

Variance decomposition of Y				
Period	Y	REG	NEG	CO_2
1	100.000	0.000	0.000	0.000
2	91.884	6.959	0.352	0.805
3	85.016	12.836	0.438	1.710
4	84.061	13.018	0.883	2.038
5	82.326	12.824	2.732	2.118
Variance Decomposition of REG				
Period	Y	REG	NEG	CO_2
1	12.033	87.967	0.000	0.000
2	9.578	85.478	4.806	0.138
3	12.406	83.045	4.342	0.207
4	12.473	81.038	6.177	0.311
5	11.870	76.213	11.389	0.528
Variance Decomposition of NEG				
Period	Y	REG	NEG	CO_2
1	97.794	0.000	2.205	0.000
2	89.464	7.263	2.363	0.910
3	82.341	12.651	3.086	1.922
4	81.672	12.735	3.235	2.358
5	81.301	12.879	3.281	2.540
Variance Decomposition of CO_2				
Period	Y	REG	NEG	CO_2
1	0.673	0.270	0.261	98.796
2	0.302	0.143	0.115	99.440
3	0.212	0.089	0.105	99.594
4	0.165	0.070	0.225	99.539
5	0.130	0.060	0.413	99.396

Indonesia. Contrary to traditional approach of assessing the impact of energy consumption, the present study analyzes the association from production point of view by assessing the impact of electricity production on economic development. In doing so, the existing study does not merely rely on aggregate electricity production but investigated the individual separate impact of RE and NRE electricity generation on economic growth of Indonesia. Witnessing the decline in energy output in Indonesian industries, the investigations on how important the two forms of power production are in stimulating country's progress is vital to plan future policies and offering governmental support to associated industries. In doing so, the current study has adopted the refined methodology of ARDL bound testing approach to examine the dynamic relationship among RE electricity generation, NRE electricity generation and economic growth with amplified understanding of the critical association to support the course of economic planning and policy making. The results of ARDL bound testing approach confirm that RE electricity generation, NRE electricity generation and carbon dioxide emission are solid determinants of economic development in Indonesia. Moreover, the results avow that RE electricity and NRE electricity generation have a useful and beneficial outcome on economic development in Indonesia

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