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Renewable Electricity Analysis of Indonesia's Green Economy: an Error Correction Model Approach

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Abstract

Fossil energy sources In Indonesia are depleting. Electricity production from fossil fuels in 2020 is 239 terawatts (TWh) or 88,73%. The high demand for non-renewable power plants is also influenced by the number of people where the higher the population in a country, the need for electricity increases. The use non-renewable power plants has increased carbon emissions. This study examines the effect of renewable electricity on the green economy in Indonesia. The objectives of this study are as follows: i) analyze how the use of renewable energy in Indonesia, ii) analyze how carbon dioxide affects, population, foreign investment, non-renewable energy, to the green economy in Indonesia. The method used in this study is an error correction model to determine the long- and short-term influence between variables. The data used in this study is from 1990-2020. The results of the study found that the variables that affect the long-term green economy in Indonesia are as fol¬lows renewable electricity, foreign investment, carbon emissions, and openness of trade. Mean¬while, the variables that affect the short-term green economy in Indonesia are as follows non-renewable electricity and foreign investment.

Keywords: renewable electricity, green gross domestic gross, error correction model

1. Introduction

Indonesia still relies on fossil energy consumption which was shown in 2018 that energy production came from coal by 64%. In addition, Indonesia also imports energy, especially petroleum and high calorie small coal which are used in the industrial sector (IEO,2019). The high demand for fossil energy that is not balanced with the energy supply causes the energy security of fossil fuels to be depleted. In addition, the increasing high use of fossil energy causes an unstable increase in greenhouse gas emissions Setyono & Kiono,(2021). Energy cosumption has a significant effect on co2 emissions by 80% which is the main source of global warming which has an effect on climate change in the long term (Mekhilef,2014). The impact of climate change in Indonesia hold up sustainable development, therefore need developing a transition from fossil energy to renewable energy resource.

Renewable energy is a source of energy produced from geothermal, wind, bioenergy, sunlight, water and temperature differences in the ocean layer. This source is renewable and environmentally friendly. The existence of new renewable energy can reduce global efficiency in fossil energy. Indonesia has considerable renewable energy potential among hydropower,

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geothermal, solar and wind power. This is also supported by government policy which refers to presidential regulation number 5 of 2005 concerning national energy policy that implements energy addition, especially energy renewable. Indonesia's commitment to increase its renewable energy target from 23% to 31% by 2050. However, until 2014 the renewable energy mix was only 6% (Bashir,2021). This is an opportunity for the country's economy to not only depend on one type of energy source. Renewable energy in addition to reducing greenhouse gas emissions also promotes a sustainable economy. However, investment in renewable electricity is still small due to large costs that must be incurred and benefits are small. Renewable electricty need to be developed, especially in office buildings that almost entirely use electricity from fuel oil and coal. This also affects the Paris Agreement where Indonesia as a country must start reforming the energy sector and reducing fossil fuels (Maulidia,2019). The existence of green economy aims to reduce pollution, human health, and biodiversity systems. This green economic concept policies conventionally with the potential of natural resources. The existence of a green economy emphasizes environmentally friendly economic progress and supports pollution reduction and socially inclusive development. Green economic growth aims to equalize the improvement of social welfare and reduce ecological damage to the environment (Harisman,2012). A similar study was also renewable electricity by Cerdeira Bento & Moutinho, (2016) which states that the degree electricity renewable important role in loweing pollution over time. Based on the background of the problems, the purposed research discussed are i) analyzing how the use of renewable electricity in Indonesia, ii) analyzing how carbon dioxide affects, population, foreign investment, non-renewable electricity, renewable electricity to the green economy in Indonesia.

2. Method

The data used in this study is from 1990 -2020. The variabel independent used include renewable electricity (million kilowatts), fossil fuel electricity (million kilowatts), co2 emissions (metric tons per capita), population (soul), foreign investment (US$) and open trade (US$). Meanwhile, the dependent variable used is green gross domestic gross (US$) to analyze how the relationship between green GDP in Indonesia to renewable electricity. The data sources used as from the world bank, energy information administration (eia) and international energy agencies, and the Climate change Indicators Dashboard. green GDP here is a development of conventional GDP by adding several environmental aspects and economic indicators. the calculation of green GDP provides a more realistic economic structure by adding elements of depletion and environmental degradation. The calculation of green GDP with the following equation Hari Kristianto,(2020) and (Wang, 2011):

$$ggdp = GDP - Depletion\ of\ Natural\ Resources - Costs\ of\ Pollution$$

Description:

ggdp: green gross domestic gross (current US$)

gdp: gross domestic gross (current US$).

International trade has a significant influence in increasing co2 emissions. This is shown from research (Widyawati,2021) where there is a short-term unidirectional causality relationship

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between trade openness, urbanization to carbon emissions. The ratio of trade openness and variables used in this study can be described in the table as follows:

Table 1. research data

Variables	Unit	Explanation	Source
Green gross domestic gross	US$	The economic output of the result of the sum of goods and services over a certain period of time and reduced by the ost of environmental depletion.	World bank
Renewable electricity	Kilowatt hours	Power source coming from	International energy agency (IEA)
Non-renewable electricity	Kilowatt hours	Sources of electricity derived from petroleum, natural gas, coal, and other baka materials include non-renewable peat.	International energy agency (IEA)
Co2 emissions	Metrics per capita	Sources of electricity derived from geothermal, solar, tidal seawater, biomass, and hydropower that can produce power plants	World bank, climate change dashboard
Population	Soul	People living in a country	World bank
Openness of trade	percent	The ratio of the sum of total exports to imports to gross domestic product (real GDP)	World bank

2.1 Analysis Steps

The method used in analyzing the influence of independent variables on the dependent error correction model (ECM) to assess short-term equilibrium relationships (short runs) The advantages in this model are able to examine the consistency of empirical models with economic theory. This model is able to find solutions to the problem of non-stationary variables and lancnung regression Widyasari & Sugiarto,(2016). In obtaining the model it takes several stages through

Step 1. Unit root test

The root test of the unit is used to find out whether the data used is stationary or not. This test is used to see a specific coefficient in the autoregressive model of each variable. In calculating the static value, it is carried out with the DF (Dickey Fuller) and ADF (Augmented Dickey Fuller) tests. Researchers used the T test and the F test which were used to see the comparison of the t value with the statistical critical value as follows:

$$DX_t = a_0 + a_1 BX_t + \sum_{i=1}^{k} b_i B^1 DX_t \quad \text{..... (1)}$$

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$$DX_t = c_0 + c_1 T + c_2 BX_t + \sum_{i=1}^{k} b_i B^1 DX_t \quad \text{..... (2)}$$

Where:

DX = $X_t - X_{t-1}$

BX_t = X_{t-1} (variable observed in period t-1)

X_t = specific trend

B = backward lag operator

K = $n^{1/3}$ (n is the number of observations)

Step 2. Cointegration test

If all the data is known to be non-stationary at the level with the Dickey-Fuller test, it will be followed by cointegration testing with the aim of determining the relationship of balance to non-free variables in long-term. Cointegration testing was performed using the Johansen Co integration test. As for the ADF stationaryity test on$\Delta\varepsilon_t = \delta\varepsilon_{t-1} + \sum_{i=1}^{k} \beta_i \Delta\varepsilon_{t-1} + \varepsilon_t$

Ifε_t the stastioner means that Y_t and X_t are co-integrated

Step 3. Model specifications

The ECM estimate used in this study is the Catao-Falcetti model estimate. ECM is a model that incorporates adjustments to make corrections to imbalances. The estimation of the error correction model can be carried out further. The models used in this study are as follows:

Long-term ECM model

$$\log(GGDP) = \beta_0 + \beta_1 \log(co2) + \beta_2 fdi + \beta_3 \log(foe) + \beta_4 (ren) + \beta_5 \log(pop) + \beta_6 (to) + e_t$$

Short-term ECM model

$$d(\log(ggdp) = \beta_0 + \beta_1 d(\log(co2) + \beta_2 d(\text{fdi}) + \beta_3 d(\log(foe)) + \beta_4 d(\log(ren)) + \beta_5 d(\log(pop)) + \beta_6 (to) + e_t$$

Where:

d(log(ggdp)) = $\log\ (ggdp)_t - \log\ (ggdp)_{t-1}$

d(log(co2)) = $\log\ (co2)_t - \log\ (co2)_{t-1}$

d(fdi) = $fdi_t - fdi_{t-1}$

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d(log(foe)) $= \log (foe)_t - \log (foe)_{t-1}$

d(log(ren)) $= \log (ren)_t - \log (ren)_{t-1}$

d(log(pop)) $= \log (pop)_t - \log (pop)_{t-1}$

d(to) $= to_t - to_{t-1}$

preliminary conjectures or hypotheses in this study

3. Results

3.1. Renewable electricity in Indonesia

Indonesia is known to have abundant energy resources, especially coal, natural gas, and geothermal, but is still facing an electricity crisis. In 2020 the installed power generation capacity reached 72,750.72 MW consisting of PLN plants of 43,186.53 MW and non PLN of 29,254.19 MW. Meanwhile, the electrification ratio is a comparison of household with the number of households in 2020 reaching 99.20%. This supports the equitable distribution of power plants in Indonesia. Supporting the existence of energy security Indonesia has a fast track electricity program policy that aims to increase power generation capacity Sugiawan & Managi,(2016). The program is divided into two, namely the use of fossil fuels and encourages the government to develop renewable electricity. Based presidential regulation no.4 of 2016 concerning the acceleration of electricity infrastructure, mandating that the implementation of infrastructure prioritizes new energy renewable this is supported by the ease of licensing, the determination of the purchase price of electricity from each type of renewable energy and the provision of electricity that sold to PLN. Renewable electricity in Indonesia are dominated by coal-fired power plants at 35.21%, PLTG at 8.80% hydropower at 10.28%, PLTM at 8.17% and solar power plants at 0.05%. The types of new renewable energy sources in Indonesia are described in the figure as follows:

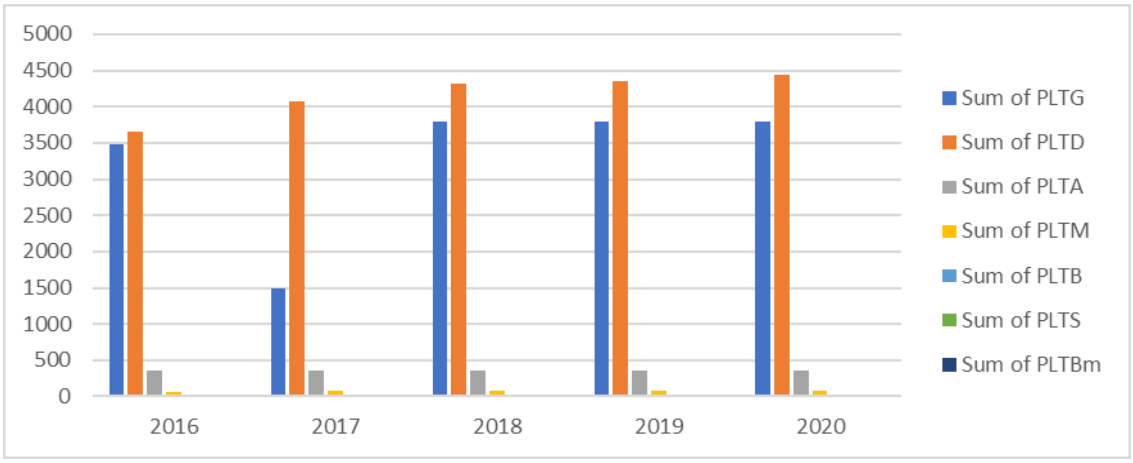

Figure 1. Capacity electricity in Indonesia (MW)
Source: BPS, 2022

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Based on the picture above, it can be seen that power plants in Indonesia are dominated by gas and steam power plants (PTG) in 2016 amounting to 3,486.16 MW in 2017 amounting to 1,493.16 MW in 2016. 2018-2020 amounted to 3799.36 MW. Such power plants are often used on types of power plants using hot air to rotate turbines. This electricity generation process has emissions that are more environmentally friendly compared to coal-fired power plants. Adiesel-powered power plant (PLTD) is a diesel engine as a prime mover (young mover).

3.2. Interpretation model

Unit root test variable testing. We apply the ADF (Augmented Dickey Fuller) test. Such results are depicted in table 2. Which shows that all variables are found stationary in the first order. Stationary is used as one of the conditions for regression results so as not to be called *spuriois regression*. Spurious regression occurs when the regression efficiency is significant and the determination value is high. However, the relationship between independent variables and dependent variables is not significant (Maruddani, 2008).

Table 2. Stationaryity test

levels				First differences			
Variables	ADF-test statictics	Lag legth	5% critical values	Variables	ADF-test statictics	Lag legth	5% critical values
co2	2.250586	5	2.938987	D(co2)	-6.104006	0	-2.941145
fdi	-1.063372	0	-2.938987	D(fdi)	-7.619580	0	-2.941145
Pp	-2.896468	5	-2.938987	D(pp)	-8.334715	0	-2.941145
Ren	-0.147757	0	-2.938987	D(ren)	-6.401937	0	-2.941145
ggdp	0.762299	2	-2.941145	D(ggdp)	-3.930744	2	-2.941145

Source: processed data, 2022

Stationary tests at the level can be seen that the value of t-ADF is greater at a significance level of 5%. Therefore, it is necessary to test the roots of the unit at the first difference level in order to get the best ADF test model. So that in the stationary test, the first difference in the level of ADF-test was greater than the significance of 5% which implied that in this study it was integrated in order I. table 3 found co-integration results that indicate that there is a long-term relationship between variables. This step is carried out to form a residual series of the OLS equation that has been carried output previously. The ECM model was applied to econometric analysis for time series data in the 1960. Error correction models (ECM) have the ability to analyze long-term and short-term economic capabilities. If Yt and Xt have a long-term cointegration influence between the two variables, there can be an imbalance *(disequilibrium)*

between variables. In the short term, it is necessary to correct the error with the *error correction model* Astuti & Saputro, (2018).

Table 3. Log term Analysis

Dependent variable = log(GGDP)				
	coefficient	Std.Error	t-Statistics	Prob.
constant	-320,5452	83,62245	-3,833244	0,0008
Log(foe)	-1,091173	0,573321	-1,903251	0,0691
fdi	2.64E-11	7.45E-12	3,547841	0,0185
Log(co2)	-1,908713	0.755550	-2.526.255	0.0185
Log(ren)	-1,374126	0,530166	-2,591879	0,0160
Log(pop)	18,13994	4,451406	4,075105	0,0004
Log(to)	0,200692	0,173314	1,157965	0,2583
r-square	0,961127			
Adjusted r-squared	0,951408			

Source: data processed, 2022

Table 3 is the result of an estimated error correction model that shows the effect of green gross domestic gross on non-renewable electricity, carbon emissions (co2), renewable electricity, population, and trade openness. The table illustrates that non-renewable electricity has a negative coefficient value against the green economy in the long run. If the ratio of non-renewable electricity increases by 1 percent, the number of green economies decreases by 1.09 percent. Non-renewable electricity variables have an insignificant relationship to the green economy in Indonesia. This shows that non-renewable electricity has no influence in the long term of the green economy in Indonesia. This is because non-renewable electricity sourced from coal, etc. produces high co2 emissions. This is in line with Research Cerdeira Bento & Moutinho,(2016). As for foreign investment, it has a positive co-efficiency value which means an increase in foreign investment by 1 percent, then the green economy will increase by 1.64 percent. Foreign investment variables have a significant effect on the green economy. This is the same as research from (Yue,2016) which states that foreign investment has an effect in improving the green economy in china. The journal discusses the efficiency of green growth that pays attention to economic and environmental indicators. this certainly affects clean techology that is environmentally friendly. Renewable electricity variables have a negative coefficient against the green economy in the long run. If renewable electricity increases by 1 percent, the number of green economies will increase by 1.37 percent. Renewable electricity variables have a significant relationship to the green economy. this is in line with Research (Mekhilef, 2014) which is transitioning conventional energy into renewable energy. The Malaysian government is developing a renewable energy project because it is considered more promising as an alternative to conventional energy sources. It also supports Kyoto's program in reducing greenhouse gas emissions. The existence of new and renewable energy projects also contributes to reducing co2 emissions. This program is also felt to be able to conserve forests and natural resources from pollution. Changes in geographical conditions such as regional ecosystems and population

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movement can affect the level of electricity demand, pollution of water surfaces, air, and soil. An increase in population movement can reduce the green economy (Staub, 2010). The open trading variable has a positive coefficient against the green economy. If open trade increases by 1 percent, then the green economy will increase by 0.20 percent. Open trade variables do not have a significant effect on the green economy because the indonesian economy still relies on a conventional economy that has not paid attention to environmental quality in the term long.

Table 4. Short Term Analysis

Dependent variable = d(log(ggdp))				
	coefficient	Std.Error	t-Statistics	Prob.
Constant	-0.022802	0.320883	-0.071059	0.9440
d(log(foe))	0.201970	0.090715	2.226.424	0.0371
d(fdi)	3.11E-11	1.26E-11	2.470.615	0.0221
d(log(co2)	-0.219192	0.862978	-0.253995	0.8020
d(log(ren))	-1.028.801	0.598270	-1.719.627	0.1002
d(og(pop))	7.832.015	2.292.216	0.341679	0.7360
d(log(to))	0.393069	0.197920	1.986.004	0.0602
e(-1)	-0.666287	0.235136	-2.833.631	0.0099
r-square	0,524951			
Adjusted r-squared	0,366601			

Source: data processed,2022

Table 4 illustrates the results of the estimate with a short-term *error correction model* having a residual coefficient value of e(-1) of 0.666287 and a probability value of 0.0099 < 0.05 or a degree of confidence of 5%. This is in accordance with the criteria of ECM-EG which must be of negative and significant value. So that this research is valid and in accordance with the requirements of residual value. Non-renewable electricity sourced from coal fuel, petroleum has a positive coefficient for the green economy in Indonesia. If non-renewable electricity increases by 1 percent, the green economy will increase by 0.20 this is because in the short term the green economy in Indonesia is still dominated by non-renewable power plants. This is because the utilization of new and renewable energy is still low. The variable foreign investment has a positive coefficient on the green economy and has a significant effect on the green economy in Indonesia in the short term. If foreign investment increases by 1 percent, the green economy will increase by 3.11. As for carbon emissions, renewable electricity, population and openness of trade have a probability value of > 5%.

Conclusion

The study uses an error correction model approach to estimate the influence between co2 emission variables, renewable electricity, non-renewable electricity, trade openness, population, in the long term and short of the green economy in Indonesia. The results of the study show that in the long term variabel which has a significant effect on the green economy, namely foreign investment, renewable electricity, non-renewable electricity, co2 emissions, population.

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Meanwhile, in the short term, the variables that have a significant effect on the green economy in Indonesia are non-renewable electricity and foreign investment.

While the suggestions put forward in this study: i) needs encouragement in developing renewable power plants in indonesia, so that people in indonesia do not depend on renewable power plants from coal. Due to the long-term impact on the environment, ii) needs to increase foregn investment and sort out investments with sustainable development goals. iii) needs for developing renewable electricity policies, especially in areas with low acces to electricity.

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