The Increase of Energy Consumption and Carbon Dioxide (CO_2) Emission in Indonesia

Hadi Sasana [1,*] and *Annisa* Eka Putri [2]

[1]Economics and Business Faculty , Diponegoro University, Semarang - Indonesia

Abstract. In the last decade, the increase of energy consumption that has multiplied carbondioxide emissions becomes world problems, especially in the developing countries undergoing industrialization to be developed ones like Indonesia. This aim of this study was to analyze the effect of fossil energy consumption, population growth, and consumption of renewable energy on carbon dioxide emission. The method used was multiple linear regression analysis with Ordinary Least Square approach using time series in the period of 1990 - 2014. The result showed that fossil energy consumption and population growth have a positive influence on carbon dioxide emission in Indonesia. Meanwhile, the consumption variable of renewable energy has a negative effect on the level of carbon dioxide emissions produced.

1 Introduction

The development of science and technology initially aiming to facilitate human work has caused new unrest and fear for human life as it has created negative implications to environment such as greenhouse effect that affects extreme climate changes on earth caused by increased carbon dioxide emissions. This effect disrupts the ecosystems of forest and others that function to absorb and reduce carbon dioxide.

Yang and Li [1] identified that technological advances lead to a rebound effect on carbon dioxide emissions in 30 provinces in China. Liberty, et al [2] who conducted a study by analyzing the impact of the natural resources used on the environment in Nigeria, a rich country in mineral resources like Indonesia, found that the natural resources greatly contribute to the national wealth and the people socially and economically, but, at the same time, a common problem of inadequate infrastructure emerges. Therefore, they suggested that both the government and the private sector should minimize waste through sorting, recycling, and pollution control. In addition, the government had to provide appropriate regulations, established law enforcement, and policy implementation. Meanwhile, the growing of the population as energy consumers results in the increased consumption of energy in aggregate, which drives a country to produce and provide more energy in order to meet their needs. The increase in the number of population can also lead to urbanizationthat has a positive and significant influence on energy consumption[3].

The increased energy consumption has resulted in the declining of the environmental quality. Impaired environmental quality can be measured by the increasing emissions or pollutants caused by energy exploration. In the long run pollutants can cause negative effects in the form of water, soil, and air contamination. One indicator that can be used to identify the amount of air pollution is to measure the levels of carbon dioxide emissions in the air due to energy exploration. According to U.S Energy Information Administration [4], human lifestyle triggers carbon dioxide as the largest emission or pollutant causing green house effect. The study of Ruijven et al [5] used CO_2 indicator because this gas is produced from production processes in various industrial sectors, including chemical and mining industries. In the cement industry, for example, every kg of cement produced contributes 0.5 kg of CO_2 emissions into the air. Therefore, CO_2 emissions becomes an indicator used by all sectors to measure air quality.

Meanwhile, Indonesia, the developing countries with abundant natural resources, according to World Resource Institute, is the 6th largest greenhouse gas emission-producing country. Some of the Indonesia's natural resources are potentially energy sources, both fossil and renewable, which might boost its economic development. Gerelmaa and Kotani [6] stated that abundant natural resources have a positive impact on economic growth. They identified countries having abundant natural resources in 1990 experienced good economic growth in the period of 1990 to 2010.

Liberty et al. [2] stated that the use of natural resources is essential in order to sustain life. Human being cultivates natural resources, either renewable or non-renewable, to produce sustainably supporting system to maintain population wellbeing by creating them for economic stability and social development. All life on earth is supported by energy and the sun. Plants and animals can store energy and some of them still exist even when the plants and animals have perished. The remains of ancient animals and plants form fossil energy.

* Corresponding author: hadisasana@live.undip.ac.id

The fossil energy is an unrenewable one that will run out at some point in time, and burning it produces greenhouse gases; therefore, fossil energy cannot be relied upon for energy generation. Consequently, renewable and sustainable energy that can be used repeatedly are needed.

Carbon dioxide (CO_2) is a chemical compound consisting of two oxygen atoms bonded covalently with a carbon atom. CO_2 is gaseous at the state of standard temperature and pressure and is present in the Earth's atmosphere. In addition, CO_2 is a colorless and odorless gas that can be produced by all animals, plants, fungi, and microorganisms. CO_2 can also be produced from the side effects of burning fossil energy.

Thao and Chon [7] stated that energy consumption has a positive impact on economy, but not to the environment. Energy consumption is widely known as the main reason for global warming and climate change to happen, particularly the consumption of fossil energy. The environmental adverse effects of such energy used are not only coming from the energy consumption but also from the exploitation process. Meanwhile, the renewable energy consumption has a negative relationship to CO_2 emissions, which means that an increase in the consumption of renewable energy will reduce CO_2 emissions.

Shi [8] argued that population growth can increase total carbon dioxide emissions, both in developed and developing countries. Thus, the larger the population is, the higher the human activity will be, which leads to the more energy is demanded. Shi [8] also concluded that if there is an increase in population by 1 percent, the emissions will increase by 1.28 percent in average. In addition, the impact of population growth on CO_2 emissions is significant in developing countries such as Indonesia than in developed countries. The study of Fei Li et al [9] using panel data from 28 Provinces in China found that energy consumption and economic growth, in long-term, affect CO_2 emissions, but CO_2 emissions and long-term economic growth have an impact on energy consumption.

Meanwhile, Ito [10] found that fossil energy consumption has a negative impact on economic growth in developing countries, and renewable energy consumption has a positive effect on economic growth. In this case, the consumption of fossil energy can cause pollution and environmental damage because the remaining burning of fossil energy is harmful to the environment; while, the renewable energy residue is considered more environmentally friendly. Moreover, Shafei and Ruhul [11] who conducted a study on OECD countries on the Kuznets Curve Hypothesis (EKC) between urbanization and CO_2 emissions found that non-renewable energy consumption has a positive relationship to CO_2 emissions, which means that an increase in non-renewable energy consumption will increase CO_2 emissions. In contrast, renewable energy consumption has a negative relationship to CO_2 emissions, which means that an increase in the consumption of renewable energy will reduce CO_2 emissions.

Given this description, this study aims to analyze the effect of fossil energy consumption, population growth, and renewable energy consumption on carbon dioxide emissions in Indonesia.

2 Research Method

This research used secondary data with Ordinary Least Square (OLS) regression analysis technique to investigate the influence of fossil energy consumption, population growth, and renewable energy consumption as the independent variable on carbon dioxide emission in Indonesia as the dependent variable. The data used were time series data from 1990 to 2014. In the time-series data, Logarithm Natural Equation (Ln) model was used to facilitate the estimation. In addition, Gujarati [12] proposed that the reason for choosing Logarithm Natural Function (Ln) is to close the data scale and to transform the data in case of deviation of classical assumption takes place. Thus, the estimated basic model is as follows:

$$CO_2 = (Pop, Fosil, R) \quad \text{.....1}$$

$$lnCO_{2t} = \alpha_0 + \alpha_1 Pop_t + \alpha_3 Fosil_t + \alpha_4 R_t + \mu_t \quad \text{.....2}$$

Note:

CO_2	=	Total emissions of carbon dioxide (CO_2) generated from energy consumption in Indonesia
Pop	=	Population growth
Fossil	=	Fossil energy consumption
R	=	Share of renewable energy consumption to total energy consumption
α_0	=	Intercept
α	=	Value of variable coefficients
t	=	1,2,3, ..., 25 (time series data of 1990 - 2014)
ln	=	Natural log (LN)
μ	=	Error term

3 Results And Discussion

Indonesia, located in Southeast Asia, is an archipelago country having approximately 17,000 islands with 1,922,570 km2 land and 3,257,483 km2water. Indonesia is the fourth most populous country in the world after China, India, and the United States. In 2016,its population was 263,846,946 million that make Indonesia has advantages as well as challenges for the future. Amid the imbalanced global economic recovery, the economic performance of Indonesia has continued to improve since 2010 marked by the economy growth in all sectors. In 2012, Indonesian economic growth was 6.5 percent; the highest figure in the last ten years[13]. The high rate of the economic growth was followed by the escalation in industrialization. Along with the growth of industrialization and population, the primary energy consumption in Indonesia also enlarged.

The higher consumption of energy led to greater CO_2 emissions or pollutants. CO_2 would continue to increase

along with the increasing rate of industrialization in many developing countries, especially in Indonesia. In 1990 – 2014, there was an increase of carbon dioxide emissions as many as 0.045 million metric tons or 4.5% per year.

3.1 Description of the Variable

Table 1 exhibits that the average emissions of carbon dioxide in Indonesia is 5.7%, the average of the population growth is 1.4%, the average consumption of renewable energy is 45.5%, and the average consumption fossil energy is 62.1%.

Table 1. Descriptive Statistics of Research Variables

Var	Mean	Median	Max	Min	S.D
Ln CO_2	5.6626	5.666427	6.10256	5.0563	0.3186
POP	1.4241	1.352808	1.78145	1.2602	0.1526
R	45.458	44.37160	58.5976	38.066	6.5434
FOSSIL	62.109	62.44202	67.1548	53.431	3.6272

Source: Secondary Data, processed

3.2 Research Result

The result of the regression estimation of the variable of fossil energy consumption, population growth, and consumption of renewable energy to carbon dioxide emission in Indonesia during 1990 – 2014 by using regression method of Ordinal Least Square is as follows.

Table 2. Regression results

Variable	Coeffi	Std. Err	t-Statistic	Prob.
C	6.449592	1.324913	4.867938	0.0001
POP	1.417481	0.421336	3.364249	0.0029
R	-0.074606	0.012339	-6.046490	0.0000
FOSSIL	0.009431	0.015036	0.627216	0.5373
R-squared	0.964246	Mean dep.var		5.66257
Adjusted R2	0.959138	S.D. dep var		0.31862
S.E. of regr	0.064408	Akai criterion		-2.5015
Sum squ resid	0.087115	Schwarz criter		-2.3065
Log likelihood	35.26900	HQ criter.		-2.4474
F-statistic	188.7812	DW stat		1.31667
Prob(F-stat	0.000000			

The result of the regression estimation reveals that R2is equal to 0.964246, meaning that 96.4% of the dependent variable could be explained by the independent variable, and the rest of the 3.6% was explained by the variable of the outside model. At the significance level of $\alpha = 5\%$ with F prob = 0.00000, it could be concluded that simultaneously the variable of the population growth, renewable energy consumption, and fossil energy consumption influenced the amount of carbon dioxide emission in Indonesia. Begum et al. [14], on the effect of energy consumption and population growth on carbon dioxide emissions in Malaysia, reported that energy consumption has proven to have a positive effect on carbon dioxide emissions; while, population growth does not significantly affect the emissions of carbon dioxide.

Further analysis of this study found that the population growth had a significant positive effect on the amount of carbon dioxide emissions in Indonesia with a coefficient of 1.417481, which meant that if the population growth increases, the emissions of the carbon dioxide will also increase linearly. The population growth is one aspect that greatly affects the increase of carbon dioxide emissions around the world in the last two decades (Shi, 2001), in particular, the effect of the population growth in China positively and significantly affect carbon dioxide emissions [15].In addition, Wang et al [16] also stated that the population growth has a strong influence on the increase of carbon dioxide emissions in 30 provinces in China.

Furthermore, Yazdi, et al. [17] who conducted a research in Iran from 1975-2011 accounted that the population growth in Iran has a positive and significant relationship to CO_2 emission with the elasticity ratio of the CO_2 emissions to population growth is 0.97. Meanwhile, Yeh and Liao [18] found that the population growth has a positive impact on carbon dioxide emissions; the more the number of the population is, the more carbon dioxide emission are generated. Communities consume energy for various purposes; so that, the more the number of the population growth, the more energy consumption is demanded that result in the increased carbon dioxide emissions.

Further findings of this study was that the renewable energy consumption negatively affected the amount of carbon dioxide emissions in Indonesia. With the coefficient of -0.074606, the figure meant that if the consumption of renewable energy increases, the carbon dioxide emissions will be reduced. Similarly, Fathinah and Djoni [19] found that the estimation result has a negative and significant relationship between the proportion of renewable energy consumption and carbon dioxide emissions in ASEAN. Another finding by Bilgili et al. [20] also showed that the amount of renewable energy consumption has a negative and significant impact on the carbon dioxide emissions. This finding might indicate that the consumption of renewable energy could significantly reduce the carbon dioxide emissions. In this case, the increasing consumption of renewable energy was expected that reducing the dependence on fossil energy consumption would reduce the carbon dioxide emissions.

The study of Paramati et al. [21] in G20 countries concluded that the consumption of renewable energy reduces CO_2 emissions and increases the countries' economic output. A similar study conducted by Zoundi [22] found that renewable energy consumption has a negative effect on CO_2 emissions, and it is considered more environmentally friendly than fossil energy. In addition, in the long-term, the consumption of renewable energy will increase as it is efficient to replace fossil energy. Moreover, Liu et al [23] obtained similar result

for renewable energy consumption negatively affects carbon dioxide emissions in 4 ASEAN countries (Indonesia, Malaysia, Philippines, and Thailand). The estimation results indicated that an increase in renewable energy consumption could reduce carbon dioxide emissions; so that, the use of the renewable energy was encouraged to achieve a cleaner and healthier environment.

The latest finding of this study was that the effect of the fossil energy consumption on the amount of carbon dioxide emissions in Indonesia was positive but not significant. This result was similar to the one of Bulut [24] who argued that the non-renewable energy or fossils had a positive effect on carbon dioxide emissions in Turkey in 1970 – 2013. Meanwhile, Shafiei and Ruhul [11] stated that the increased non-renewable or fossil energy consumption led to the increase of CO_2 emissions in OECD countries during 1980 to 2011. Similarly, Dogan and Fahri [25] who conducted a research in European countries stated that the consumption of nonrenewable energy will increase CO_2 emissions, and there is an indirect causal relationship between CO_2 emissions and non-renewable energy consumption. Zheng-Xin and De-Jun [26] proved that the consumption of fossil energy causes an increase in carbon dioxide emissions; while, Danish et al. [27] stated that the consumption of fossil energy has a positive effect on carbon dioxide emissions in Pakistan. Fossil energy consumption was the main cause of carbon dioxide emissions, and the combustion of fossil fuels are carbon dioxide gas that might damage the environment and people's health. Chibueze et al. [28] also stated that in the short and long term, the fossil energy consumption proved to have a positive and significant influence on the carbon dioxide emissions in Nigeria in the period 1971-2009.

4 Conclusion

Given the results and discussion of this research, some conclusion can be drown:

1. Based on the results of the OLS regression, the population growth variable has a positive and significant effect on carbon dioxide emissions in Indonesia in 1990-2014.
2. The variable of the consumption of the non-renewable fossil energy has positive but not significant effect on carbon dioxide emission in Indonesia in 1990-2014.
3. The variable of the consumption of the renewable energy has a negative and significant effect on Indonesia's carbon dioxide emissions in 1990-2014.

The results of the research suggested that the increased consumption of the non-renewable energy or fossil will increase the amount of carbon dioxide emissions; on the contrary, the consumption of the renewable energy can reduce the amount of the carbon dioxide emissions. Therefore, a developing country like Indonesia where industrialization is in progress, it is very important to reduce the use of the fossil energy and shift to the renewable one. In addition, the government is also expected to provide legislation and strict law enforcement if a production produces excessive emissions thereby lowering the quality of the environment.

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