NATIONAL ECONOMIC DEVELOPMENT TRANSFORMATION IN THE DIRECTION OF LOW CARBON DEVELOPMENT

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ABSTRACT

Economic transformation toward low-carbon growth is a top objective for the country's long-term development agenda. The energy sector is the most important in reaching the country's low-carbon development goal. The success of the energy sector transition from brown to green energy will determine the success of national economic transformation process. The purpose of this study is to examine the impact of Indonesia's economic activities on the environment in comparison to peer countries, to examine the development of Indonesia's economic development process towards low-carbon development in several key stages of the national economy, to examine the linkages between the energy sector and other sectors, to examine the process of Indonesia's energy transition towards low-carbon development, and to provide policy recommendations for Indonesia. The cross-country analysis method, multiple linear regression method, input output analysis, and descriptive statistical analysis were all used in the study. The study's findings show that (1) Indonesia's economic activities caused very high environmental degradation between 1970 and 2020; (2) There is a downward trend in the risk of environmental degradation from Indonesia's economic activities, which is consistent with the momentum of the 1945 Constitution Article 33 amendment; (3) Energy sector products such as electricity, coal and lignite, natural gas and geothermal have a high forward linkage. Electricity is the input for 184 other sectors or equivalent to 99.46% of the total sector in Indonesia, as well as coal and lignite at 27.03%, then natural gas and geothermal at 16.22%. Other than that, products in the energy sector have a large multiplier effect for national output; and (4) Finally, the government should fully consider everyones' participation in Indonesia's economy and its road to developing the renewable energy based partnerships at all levels. The energy transition will be required if we are to flourish as a people, rather than simply survive, on this planet of ours. We only have one. Only renewed international cooperation and coordination of all state capabilities – a new social contract underwritten by global consensus – can make us prepared, to untangle the current interlocking crises.

Keyword: Economic Transformation, Low Carbon Growth, Energy Transition

INTRODUCTION

The world economy has been affected by the Covid-19 pandemic, which began in March 2020. The Covid-19 pandemic produced economic catastrophes all throughout the world in 2020, not just in underdeveloped countries and poor countries, but also in rich countries. The economic recession brought on by the pandemic demonstrates that the economic shock is generated by non-economic reasons as well as economic ones.

Climate change will be the world's greatest challenge after the pandemic, with an impact far greater than Covid-19. Several environmental indicators and the impact of climate change were worsening in 2020, according to the World Meteorological Organization in April 2021, CO^2 concentrations in the atmosphere increased above 300 ppm for the first time in more than 800,000 years, and are currently more than 400 ppm; worldwide mean sea levels have risen past the 1993 record high; and global average temperature has risen substantially above 1.1^0C, greater than the 1961-1990 baseline. Since the late 1990s, the Antarctic ice sheet has been shedding mass at a rapid rate of roughly 175 to 225 Gt each year; and in 2020, there were 20 significant tropical storms, the most in history.

Indonesia is a country that is extremely vulnerable to climate change (Standard & Poor's, 2014), and being an archipelagic country with over 17 thousand islands, it is particularly vulnerable to rising sea levels. Jakarta is likely to sink in the next 10 years if significant sea level rise is not anticipated, according to US President Joe Biden in his presentation to the leaders of US intelligence agencies on July 27, 2021. Indonesia's sea level is rising at a rate of 0.8-1.2 cm per year (BMKG, 2020), and 65 percent of the country's population lives in coastal areas (BPS, 2016). Indonesia witnessed a trend of increasing temperatures of roughly 0.03^0C per year from 1981 to 2018, according to BMKG figures. Furthermore, national greenhouse gas emissions climbed by roughly 4.3 percent every year from 2010 to 2018 (KLHK, 2020).

The worsening of Indonesia's environmental indicators should be a major source of worry. Climate change will pose significant dangers from both an environmental and a socioeconomic standpoint. Climate change, according to the Nationally Determined Contribution (NDC) statement, will increase the probability of hydrometeorological disasters, which now account for 80% of all disasters in Indonesia. Meanwhile, Indonesia's potential economic losses as a result of climate change will range from 0.66 percent to 3.45 percent of GDP in 2030 (KLHK, NDC Adaptation Roadmap, 2020). Climate change must undoubtedly be a high priority for the government in order to ensure the country's long-term viability and the Republic of Indonesia's integrity.

Indonesia is committed to lowering carbon emissions and combating climate change. Since 1994, when Indonesia joined the UNFCCC in Law No. 6 of 1994, several national climate change initiatives have been on the government's agenda. In addition, Indonesia has ratified many global climate agreements, including the Kyoto Protocol, which was enacted into law No. 17 of 2014 and the Paris Agreement, which was enacted into law No. 16 of 2016. With the adoption of the Paris Agreement in 2016, Indonesia became a country that was required to cut carbon emissions and give quarterly progress reports on carbon emission reductions in order to meet the emission reduction targets.

The 2020-2024 National Medium-Term Development Plan (RPJMN) lists Indonesia's carbon emission reduction commitments, with climate change mitigation as the sixth national priority. Indonesia submitted an update on its NDC and long-term emission reduction strategy (LTS-LCCR) to the UNFCCC in 2021 as a progressive step in mitigating climate change. Indonesia has committed to lowering carbon emissions by 29 percent with national efforts and 41 percent with international cooperation by 2030 under the NDC. Indonesia will undoubtedly encounter various problems in reaching these emission reduction targets, including establishing priorities for sectors that will become the leading sectors in meeting Indonesia's carbon emission reduction targets.

The creation of fairly substantial carbon emissions each year is Indonesia's main hurdle in meeting its emission reduction target. Indonesia was the eighth largest carbon emitter in 2019, with 618 million metric tons of CO^2 emitted (UNCTAD, 2021). Indonesia's carbon emissions are unquestionably a significant concern for the country. Indonesia needs to make rapid transformative efforts in order to meet the targeted emission reduction targets. Of course, the transition to low-carbon development must be carried out in a systematic and measurable manner by identifying priority sectors or leading sectors that will be the primary drivers of national carbon emissions reduction.

According to Indonesia's NDC from 2016, the forestry and energy sectors are the most important drivers of reaching Indonesia's carbon emission reduction targets. Carbon emissions in the forestry sector are expected to be reduced by 497 metric tons of CO^2e by 2030, while carbon emissions in the energy sector are expected to be reduced by 314 metric tons of CO^2e. The financing need for climate change mitigation in the forestry sector is relatively small, at IDR 93.28 trillion, whereas the financing need for climate change mitigation in the energy sector is IDR 3,500 trillion, or 92.59 percent of the total financing needs for climate change mitigation of IDR 3,779.63 trillion (KLHK, Roadmap NDC Mitigation, 2020).

The energy sector is the largest contributor to Indonesia's carbon emissions, according to data from the Emission Database for Global Athmospheric Research (EDGAR). In 2019, the energy sector accounted for 41.13 percent of Indonesia's total carbon emissions. The share of carbon emissions from the energy sector has been steadily increasing since 1970, when it was just 11.75 percent, the lowest among other sectors, then climbed to 22.11 percent in 2000, and then to 41.13 percent in 2019. The energy sector is a key input for other sectors, in addition to having a growing trend of emission contributions.

Given the certainty of the Indonesian forestry sector, the systematic process of converting Indonesia's low-carbon growth must focus on the energy sector. Because the transformation of Indonesia's energy sector produces a lot of carbon emissions and costs a lot of money, it needs to be done in a systematic and quantitative way. Given that the energy sector is an upstream sector for other sectors, Indonesia's success in changing the energy sector will be critical in attaining national low-carbon development.

This study aims to analyze the impact of environmental degradation caused by Indonesia's economic activities in comparison to peer countries, analyze the development of Indonesia's economic development process towards low-carbon development in several important phases of the national economy, analyze the energy sector's linkages to other sectors, analyze the transition process Indonesia's energy towards low-carbon development, and provide policy recommendations for Indonesia's economic and energy transformation towards

low-carbon development. Cross-country analysis was used to examine the relationship between Indonesia's economic growth and its peer countries' carbon dioxide emissions; multiple regression analysis was used to examine the direction of Indonesia's economic development towards low-carbon development in several key stages of the national economy; input output analysis was used to examine the linkages between the energy sector and other sectors; and descriptive statistical analysis and meta-analysis to analyze Indonesia's energy transition process towards low-carbon development.

LITERATURE REVIEW

Environmental Kuznets Curve Theory

Economic growth and energy consumption are the two key variables that have a strong relationship with environmental degradation, according to Zhu (2016). Economic expansion resulting from increased aggregate production will almost likely result in increased aggregate consumption of carbon dioxide-producing energy. According to the Environmental Kuznets Curve (EKC) theory, developing countries suffer from serious environmental damage, and the majority of them have poor per capita income, Lau (2014). This theory describes how low-income countries, many of which are pre-industrial or agrarian, will eventually adopt agricultural and other industrial mechanization, resulting in increased resource demand and pollution as a result of technology. In the long run, economic growth that degrades the environment makes the country aware of the expectations of increased life expectancy, cleaner water, improved air quality, and cleaner habitats, making environmental improvement a priority in economic development. The shift from pre-industrial to industrial and post-industrial economies will result in an inverted U-shaped link between a country's per capita GDP and environmental degradation Fodha (2010).

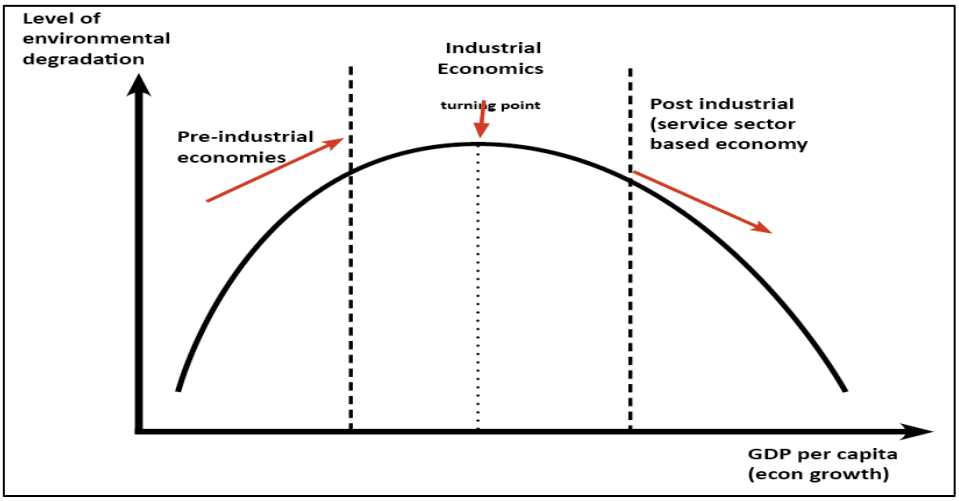

Figure 1. Environmental Kuznets Curve Theory
Source: Fodha (2010)

The Environmental Kuznet Curve hypothesis reveals that countries with high per capita incomes tend to decrease environmental degradation, while countries with low per capita incomes tend to increase environmental degradation. This can be explained that countries with

high per capita incomes that previously used non-environmentally friendly technology changed their technology to be environmentally friendly, while countries with low per capita incomes still used technologies that were not yet environmentally friendly. The use of environmentally friendly technology or renewable technology tends to be used by countries with high per capita income because generally renewable technology is quite expensive. Environmentally friendly or renewable technology is more commonly adopted by countries with a high per capita income because renewable technology is generally rather expensive.

According to Syed (2019), the structural transformation of the economy is relevant to the Environmental Kuznets Curve (EKC) concept. This theory suggests that economic development results in a structural change that transfers the economic production system from low-polluting agricultural industries to pollution-intensive manufacturing sectors and then shifts again to less carbon-intensive service sectors. Syed (2019) also doing empirical research on how the UK's economy has developed over time and the efforts it has made to reduce its carbon dioxide (CO2) emissions. Their research find that the UK has the highest net import of carbon emissions from China, which reached a peak of 103 million tonnes of CO2 emissions in 2007.

A briefing by the House of Commons states the UK's largest import from China was telecoms equipment in 2017. A study published in the Nature Climate Change Journal found that products made in China are associated with higher CO2 emissions than if the same products were made elsewhere. Liu, Z et all (2016) explain the reason because China uses less advanced manufacturing processes and relies primarily on coal for energy.

Li, Si, and Kang (2021) founds the importance of environmental information disclosure to carbon emission reduction in China. They found significance impact using Difference in Difference Method. This achievement could be explained by the positive impact of environmental information disclosure to coal withdrawal and promote public awareness. From the perspective of information flow, the research on the "spill over" impact of carbon emissions reduction that is brought about by environmental information disclosure is an important supplement to China's exploration of diversified ways to reduce carbon emissions.

One alternative to face the problem of coal withdrawal especially for coal resource producer is coal gasification. Gasification according to Bell, Tower and Fan (2011) offers relatively cost effective means of using coal while minimizing greenhouse emission.

RESEARCH METHODS

Sources and Data Types

This study relied on secondary data for its findings. Time series data for the years 1970 to 2020 were used. The secondary data needed in this study was obtained from the World Meteorological Organization (WMO),United Nations Conference on Trade and Development (UNCTAD), Emission Database for Global Atmospheric Research (EDGAR), World Development Indicators, and National Energy Council PLN Statistics, Ministry of Energy and Mineral Resources GOI, Indonesia Statistics, and Ministry of Environment and Forestry GOI. Meanwhile, the data used for input-output analysis is Indonesia's input-output table of 2016 arranged by the Central Bureau of Statistics Indonesia.

Analysis Method

The cross-country analysis method was used to analyze the impact of environmental degradation caused by Indonesia's economic activities in comparison to peer countries; the multiple regression method was used to analyze the direction of Indonesia's economic development towards low-carbon development in several important phases of the national economy; input output analysis was used to analyze the linkages between the energy sector and other sectors; and descriptive statistics were used to analyze the impact of environmental degradation caused by Indonesia's economic activities in comparison to peer countries. The following is the structural equation that was used.

1. Analysis of the influence of Indonesia's economic activities on the environment in comparison to peer countries.

   Model 1: $LnCO^2_{it} = \beta_0 + \beta_1 LnGDPCAP_{it} + \beta_2 URBAN_{it} + \beta_3 GCF_{it} + \beta_4 DUMMY_{it} + \varepsilon$

   Model 2: $LnCO^2_{it} = \beta_0 + \beta_1 (LnGDPCAP_{it})^2 + \varepsilon$

2. Analysis of the direction of Indonesia's economic development towards low-carbon development at various stages of the country's development.

   Model 3: $LnCO^2_t = \beta_0 + \beta_1 LnGDPCAP_t + \beta_2 URBAN_t + \beta_3 EXPORT_t + \beta_4 IMPORT_t + \varepsilon$

3. Input output analysis of the linkages between the energy sector and other economic sectors, then how large the multiplier effect for energy sector products to national output. Analysis of the linkages between the energy sector and other sector using the output structure analysis. The analysis is a kind of descriptive analysis that describes the role of each sector. On the other hand, to analysis multiplier effect, there is a multiplier matrix with Leontif I-O's equation.

   Model 4: $X = (1 - A)^{-1} Y$

4. Descriptive statistical analysis and meta-analysis to analyze the effect of the increase in the actual electricity price on the national economy.

   Model 5: $LnGDP_t = \beta_0 + \beta_1 SUSUT_t + \beta_2 TRANS_t + \beta_3 ACCESS_t + \beta_4 LnBPP_t + \beta_5 LnSUB_t + \beta_4 LnLEPK_t + \beta_4 LnINTENSITY_t + \varepsilon$

Note:

$LnCO^2$	=	Carbon dioxide gas emissions per capita (ton CO^2/year/capita)
LnGDPCAP	=	GDP per capita (Constant 2010, USD)
URBAN	=	Population growth in urban areas (%)
GCF	=	Gross Capital Formation (Constant 2010, USD)
DUMMY	=	Dummy of the Paris Agreement. After the signing of the Paris Agreement, the value is 1, while before the signing of the Paris Agreement, the value is 0.

Note:

EXPORT	=	Export value growth (%)
IMPORT	=	Import value growth (%)
X	=	Output Vector (Multiplier Effect)
Y	=	Final Demand Vector
I	=	Identity Matrix
A	=	Input Coefficient Matrix
$(I-A)^{-1}$	=	Leontif Inverse Matirix
LN_GDP	=	Logarithmic on nominal GDP
SUSUT	=	Energy use/own use losses
TRANS	=	Transmission and distribution losses
ACCESS	=	Access to electricity
LN_BPP	=	Logarithmic on electricity generation cost
LN_SUB	=	Logarithmic on subsidy on electricity
LN_LEPK	=	Logarithmic on low-carbon energy per capita
LN_INTENSITY	=	Logarithmic on final energy intensity
β_0	=	Intercept
$\beta_{1...}\beta_4$	=	Slope
i	=	Country
t	=	Year
ε	=	Error term

RESULTS AND DISCUSSION

Analysis of the Impact of Indonesia's Economic Activities on Environmental Degradation in Comparison to Peer Countries

The impact of economic activity on the emergence of environmental degradation is examined using many determinant variables of carbon dioxide gas emissions, as well as determinant variables that have previously been studied. Carbon dioxide gas emissions are used as the independent variable, with all other determining variables being exogenous. The regression analysis reveals that the natural logarithm of GDP per capita has a positive and significant effect in all countries, with the exception of high-income countries such as the United States and the United Kingdom, where GDP per capita has a negative and significant response to carbon dioxide gas emissions per capita. Reducing the influence of economic activities on environmental degradation in these countries, in accordance with the trend of emission movements in each country. Carbon emissions per capita are beginning to decline in nations such as the United States, the United Kingdom, and Japan, while carbon emissions continue to rise in countries such as Indonesia, Malaysia, Brazil, Australia, China, and Kenya (Fig. 2). However, given that the process of economic transformation towards a low-carbon economy began when these industrialized countries reached the peak of their industrial phase in the mid-1980s.

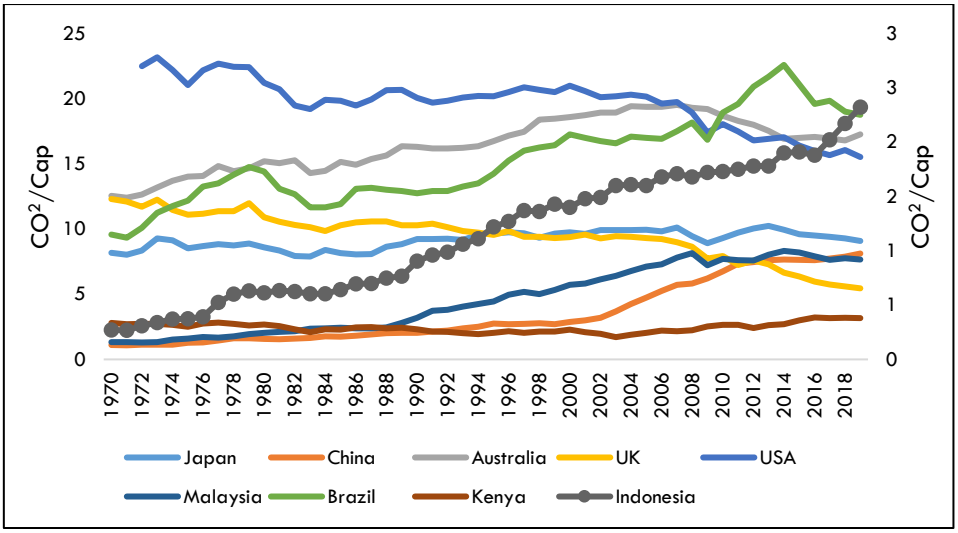

Figure 2. Carbon Dioxide Emissions Per Capita Development
Source: Emission Database for Global Atmospheric Research (EDGAR)

The effect of the natural logarithm of the square of GDP has the same effect as the natural logarithm of GDP variable, where the shape of the curve is concave between the relationship between per capita income levels and environmental degradation in developed countries, such as the United States and the United Kingdom, while in low and middle income countries, the shape of the curve is convex. The curve has a convex form as it descends. This demonstrates that the Environmental Kuznets Curve theory only applies to groups of high-income countries. This is in line with the Environmental Kuznets Curve hypothesis, which states that high-income countries are more likely to reduce environmental degradation than low- and middle-income countries. This is because low- and middle-income countries tend to exploit resources more intensively, and environmental improvements are costly, so low- and middle-income countries tend to consume more than reduce environmental degradation, Todaro (2003); Balke (2011); Arfanuzzaman (2016); Wang (2016); Chen (2016); Zakarya (2015).

In general, the signing of the Paris Agreement had an impact on reducing carbon emissions, except in Brazil, China and Kenya. This condition indicates that countries who have signed the Paris Agreement are more committed to reducing carbon emissions from their economic operations. This condition also shows that a stronger global consensus on climate change mitigation gives reason for optimism that the global carbon emission target of 2 - 1.5^0C per year can be met. Table 1 shows the findings of the estimation of the impact of economic activity on the emergence of environmental degradation.

Table 1. Estimated Economic Impact on the Environmental Degradation

LnCO²	**Indonesia**	**Malaysia**	**Brazil**	**Australia**	**China**	**Kenya**	**Japan**	**USA**	**UK**
_Cons	**-12,972****	**-9,930****	**-5,715****	**-2,032****	**-2,826****	**-4,440****	-0.545	**4,434****	**4,369****
LnGDPCAP	**1,762****	**1.318****	**0.708****	**0.478****	**0.429****	**0.378****	**0.258****	**-0.187****	**-0.232****
URBAN	**0.110****	**0.042***	**-0.056****	**-0.040****	-0.001	**0.047****	**0.025****	**0.065****	-0.048
LNGCF	**-0.031****	**-0.007****	0.001	-0.006	0.025**	**0.019****	0.001	**0.021****	**0.016****
Dummy	**-0.222****	**-0.276****	0.015	**-0.157****	0.026	**0.252****	**-0.025****	**-0.113****	**-0.367****
R-squared	0.982	0.989	0.908	0.910	0.985	0.710	0.614	0.825	0.902
Prob F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(LnGDPCAP)2	**0.080****	**0.069****	**0.054****	**0.020****	**0.039****	**0.038****	**0.009****	**-0.015****	**-0.232****

LnCO²	Indonesia	Malaysia	Brazil	Australia	China	Kenya	Japan	USA	UK
R-squared	0.935	0.968	0.900	0.739	0.982	0.945	0.551	0.588	0.902
Prob F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

** Significant at 5%, * Significant at 10%,
Source: The regression results of the researcher

In comparison to other countries, Indonesia's GDP per capita variable has the highest coefficient value on carbon dioxide gas emissions. When Indonesia's GDP per capita rises by 1 percent, its carbon dioxide emissions will rise by 1.762 percent. An increase in Indonesian economic activity has the potential to produce significant carbon emissions; a 1 percent increase in domestic economic activity will result in 2x carbon emissions. This situation demonstrates that Indonesia's economic activity has a high environmental impact; in fact, when compared to other countries, Indonesia's economic activity has the greatest impact on the environment.

Analysis of Indonesia's Economic Development Pathway Towards Low-Carbon Development at Several Key Stages of the National Economy

According to a comparison of the influence of economic activity on environmental deterioration between 1970 and 2020, Indonesia's economic activity produced the most environmental damage. This situation poses a significant challenge for Indonesia, particularly in terms of achieving the NDC target of decreasing carbon emissions by 29 percent with national efforts and 41 percent with international assistance by 2030. Indonesia, on the other hand, has made a major commitment to climate change mitigation. "The national economy is organized based on economic democracy with the principles: togetherness, efficiency, justice, sustainability, environmental insight, independence, and by maintaining a balance of progress and national economic unity," according to Article 33 paragraph 4 of the 1945 Constitution, which was amended in 2002.

This section will examine the direction of Indonesia's economic development toward low-carbon development, which is divided into three analysis phases: the oil boom phase and the development of domestic industry in 1970-1992; the phase before the 1945 Constitution Article 33 Paragraph 4 amendment in 1990-2002; and the phase after the 1945 Constitution Article 33 Paragraph 4 amendment in 2003-2020. Table 2 shows the findings of the estimation of the direction of Indonesia's economic development in three key stages of the national economy.

Table 2. The results of the estimation of Indonesia's economic development direction in three major stages of the national economy

LnCO²	Phases of the Oil Boom and the Development of Domestic Industry (1970-1992)	Phase before the Amendment of the 1945 Constitution Article 33 (1990-2002)	Phase After Amendment to the 1945 Constitution Article 33 (2003-2019)
_Cons	**-11,1107****	**-6.3258****	-2.3047**
LnGDPCAP	**1.4640****	**0.9291****	**0.3829****
URBAN	0.0170	**0.1255****	-0.0742
EXPORT	-0.0021	0.0024	0.0006
IMPORT	**0.0037****	**-0.0039****	-

$LnCO^2$	Phases of the Oil Boom and the Development of Domestic Industry (1970-1992)	Phase before the Amendment of the 1945 Constitution Article 33 (1990-2002)	Phase After Amendment to the 1945 Constitution Article 33 (2003-2019)
R-squared	**0.9578**	**0.9113**	**0.9139**
Prob F	**0.0000**	**0.0002**	**0.0000**

** Significant at 5%, * Significant at 10%,
Source: The regression results of the researcher

The second oil boom (the Iran-Iraq war) in 1978 resulted in an increase in Indonesia's export income from USD 11.64 billion in 1978 to USD 25.16 billion in 1981. Oil prices rose from USD 15.65 per barrel in 1979 to USD 35 per barrel in 1981-1982. During the oil boom, Indonesia's income surged, allowing it to purchase capital goods and manufacturing raw materials to create domestic industries, notably import substitution industries, from 1982 to 1989. Indonesia's imports climbed by 286.92 percent throughout the time period. Carbon emissions tended to rise during the oil boom and increased industrial activity until the 1945 Constitution's Article 33 paragraph 4 was amended. According to the regression results (Table 2), a 1% rise in GDP per capita during the oil boom and domestic industrial development stages will result in a 1.46 percent increase in carbon dioxide emissions.

This indicates that economic activity at the time tended to produce high emissions, which coincided with an increase in domestic industrial activity, resulting in a significant increase in carbon emissions.

A rise in Indonesia's imports, in addition to the GDP per capita variable, is driving an increase in carbon dioxide emissions per capita, though the impact is minor. A 1% increase in imports will result in a 0.004% rise in carbon dioxide emissions. As previously said, Indonesia imported capital goods and production raw materials during this time in order to develop indigenous industries, including import substitution industries. Indonesia's imports climbed by 286.92 percent throughout the time period.

Environmental deterioration caused by Indonesia's economic activity decreased in the second phase (before the amendment) compared to the first phase. Carbon dioxide emissions will grow by 0.93 percent for every 1% increase in GDP per capita. Even in the third phase (post-amendment), the impact of Indonesia's economic activity on environmental degradation dropped by around 0.55 percent to 0.38 percent, implying that a 1% rise in Indonesia's economic activity will result in a 0.38 percent increase in carbon dioxide emissions. This situation indicates that the risk of environmental degradation from Indonesia's economic operations is decreasing in general, which is consistent with the momentum of the 1945 Constitution amendment.

The drop in the elasticity of carbon emissions from 2002 to 2020 was primarily due to the decline in industry's contribution to national GDP. This is strongly linked to the reduction in carbon emissions from Indonesia's industrial sector, which has been the country's main source of carbon emissions. This correlation between economic activity and environmental deterioration is consistent with the Environmental Kuznets Curve theory, which holds that as industry's contribution to the economy grows, so does environmental degradation (Figure 3).

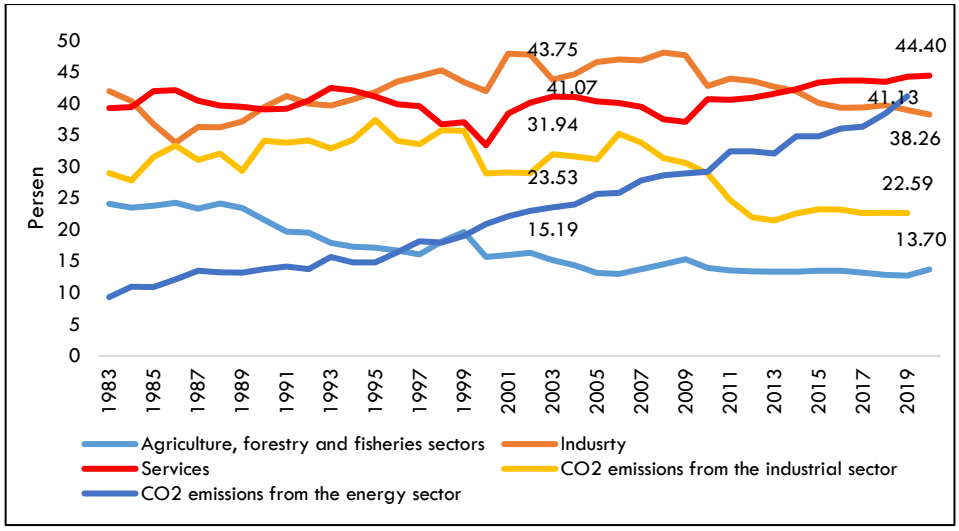

Figure 3. CO^2 Emissions from Industry and Energy Sectors, as well as GDP Distribution by Sector
Source: World Development Indicators, EDGAR

Following the fall in the contribution of carbon emissions from the industrial sector, energy sources contributed the most to Indonesia's carbon emissions (Figure 4). The energy sector is the largest contributor to Indonesia's carbon emissions, according to EDGAR data . In 2019, the energy sector accounted for 41.13 percent of Indonesia's total carbon emissions. The share of carbon emissions from the energy sector has been steadily increasing since 1970, when it was just 11.75 percent, the lowest among other sectors, then climbed to 22.11 percent in 2000, and then to 41.13 percent in 2019. The energy sector is a key input for other sectors, in addition to having a growing trend of emission contributions.

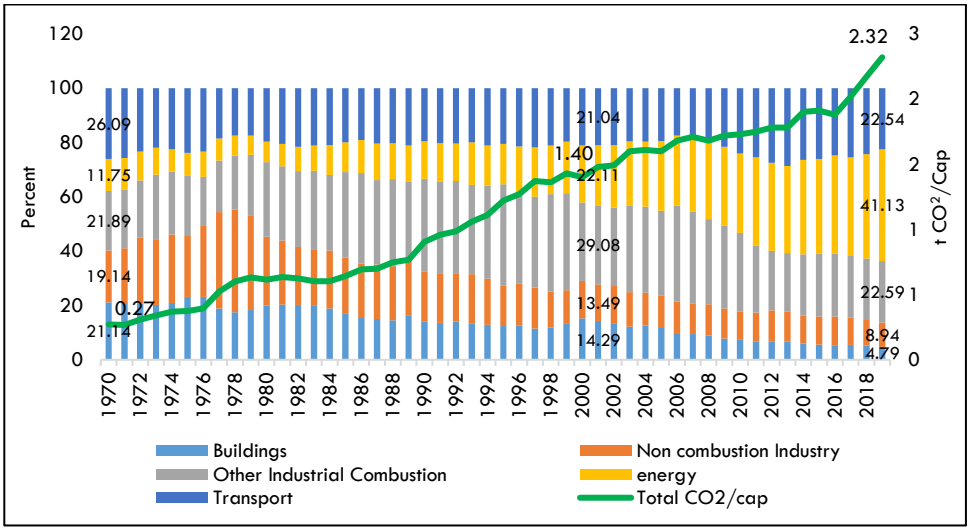

Figure 4. Indonesia's Carbon Emissions Sector as a Percentage of Total Emissions.
Source: EDGAR

Based on a multi-phase analysis of environmental degradation caused by Indonesia's economic activities, it is clear that Indonesia's economic transformation towards low-carbon development is on the right track, even if this reduction in carbon emissions is accompanied by a decline in the industrial sector's contribution to the national economy. In order to maintain the current low-carbon development trend, Indonesia's low-carbon development transformation process will need to be focused on the energy sector transformation in the

future. Because the transformation of Indonesia's energy sector produces a lot of carbon emissions and costs a lot of money, it needs to be done in a systematic and quantitative way.

Inputs and Outputs Analysis of the Energy Sector's Linkage with Other Economic Sectors

The Input-Output (IO) model is often used in analyzing macro economic system to do assessment of linkages between sectors. One of the basic theories of the IO analysis model is to look at the relationship between the distribution of outputs and the arrangement of inputs. Based on these theories or assumptions, the IO analysis model has limitations, namely the input coefficients are assumed to be constant or constant in the period to be analyzed (Rita, 2013). Input Output Analysis in this study is to determine the extent of the relationship between the energy sector and other sectors in the national economy.

The energy sector products that will be analyzed by IO are electricity, coal and lignite, petroleum, natural gas and geothermal. The analysis used in this research is the analysis of the output structure and the multiplier effect. Analysis of the output or query structure in the IO table has two types, namely intermediate demand and final demand. Intermediate demand is a demand for goods and services that are used for further processing in the production sector or are easily understood as inputs in the production process. While final demand is a type of demand for final consumption which consists of household consumption, government, capital formation and exports.

Table 3 shows that products in the energy sector generally have a higher intermediate demand value than the final demand. This indicates that most of the output of energy products is used to meet the final demand. However, if viewed in more detail, coal and lignite products have a higher final demand value than intermediate demand, meaning that coal and lignite output are mostly used to final demand.

Table 3. Output/demand structure for energy sector products (Million Rupiah)

Code	Product	Intermediate Demand	Final Demand
037	Coal and Lignite	141 783 761	274 720 419
038	Petroleum	218 262 999	72 702 276
039	Natural Gas and Geothermal	169 452 831	24 559 624
145	Electricity	213 278 298	83 681 625

Source: the results of the researcher's analysis using the IO 2016's table

Looking at the intermediate demand side, of the four energy sector products observed, Petroleum has the highest demand value, which is 218 trillion rupiah. Petroleum was ranked eighth out of 185 goods and services products, followed by electricity which was ranked tenth, natural gas and geothermal ranked sixteenth, lastly coal and lignite ranked nineteenth. Based on the final demand side, the four observed energy sector products have a strategic position and have been widely used as inputs in various sectors (Mulyani and Hartono, 2018).

Distribution of final demand on the four products of the energy sector is distributed to household consumption and export of goods. The final demand for household consumption is only met by electricity products with a demand value of 83 trillion rupiah, while three other products to meet the demand for export goods with the highest value, namely coal and lignite

at 274 trillion rupiah, even become the highest value among 185 goods and services. service. This is in line with data from the Central Statistics Agency that coal is one of the ten largest export commodities in Indonesia.

The high value of the final demand for the four energy sector products does not mean that the product is widely used as input for other sectors. Electrical products as input for 184 sectors or 99.46 percent of the sectors listed in Indonesia's IO table are 185 sectors. Meanwhile, other products, such as oil, are only inputs for 17 sectors or 9.19 percent of the total sector or at least one sector that uses petroleum products as production inputs. Further, for other energy sector products, it can be explained in Table 4. Through the analysis of the output structure, it can be seen that the energy sector products have a high demand value, but of the four products from the energy sector, only Electricity has a high involvement in the production processes of other sectors.

Table 4. Number of sectors using energy sector products

Code	Product	Number of Sectors Using Output	Percentage (%)
037	Coal and Lignite	50	27.03
038	Petroleum	17	9.19
039	Natural Gas and Geothermal	30	16.22
145	Electricity	184	99.46

Source: the results of the researcher's analysis using the IO 2016's table

The next analysis is the analysis multiplier effect. Based on the 2016 IO's table, it can be calculated the magnitude of the multiplier in the energy sector products to the national output, the multiplier calculated in this study is from forward linkages, backward linkages and total multiplier. The magnitude of the output multiplier has an interpretation that every one rupiah increase in final demand for energy sector products will affect national output.

The results of the analysis show that the largest value of multiplier effect is the electricity sector at 6.65. This means that each injection of one rupiah in the electricity sector will create 6.65 rupiah of total national output. In more detail when viewed from the side of forward linkages, the Electricity sector has a multiplier value of 4.51. This means that each injection of one rupiah will increase 4.51 rupiah of demand or revenue in sectors that use output or the downstream sector of electricity. Meanwhile, in terms of backward linkages, it is 2.14, meaning that each injection of one rupiah can attract input of 2.14 rupiah. The results of the calculation of the output multiplier value can be seen in Table 5.

Table 5. Multiplier effect of energy sector products

Code	Product	*Forward Linkages*	*Backward Linkages*	*Multiplier Effect Total*
037	Coal and Lignite	3.56	1.79	5.35
038	Petroleum	6.45	1.43	7.89
039	Natural Gas and Geothermal	5.09	1.47	6.55
145	Electricity	4.51	2.14	6.65

Source: the results of the researcher's analysis using the IO 2016's table

The results of the analysis multiplier effect show that products in the energy sector have a large multiplier effect, although based on the output structure only Electricity has the largest involvement as input for 185 other sectors. In addition, the results of the analysis show that

products in the energy sector have a large multiplier value to the total national output, meaning that if it is associated with economic transformation, involving products in the energy sector is the right step. But keep in mind if the economic transformation associated with lower carbon emissions, based on the input output analysis, electricity and gas sector is the highest carbon emitters sector in Indonesia with the carbon emissions intensity of 1.04 CO^2/Rp (Irfany *et al*, 2015). This value is two times higher than the cement sector which is in second place.

The Road to a Just Energy Transition

Energy has been critical for economic growth throughout human history, the "precondition of all commodities, a basic factor equal with air, water, and earth" (E. F. Schumacher, Nobel laureate economist, 1977) . According to the International Renewable Energy Agency, fossil fuels have been the foundation of the global energy system (International Renewable Energy Agency, 2019) and The Intergovernmental Panel on Climate Change (IPCC) found that emissions from fossil fuels are the dominant cause of global warming (Intergovernmental Panel on Climate Change, 1990). In the absence of climate change mitigation policies, energy-related CO2 emissions are expected to continue to increase.

As new energy alternatives need to be less polluting than the sources they replace, renewable energy moves naturally into center stage. Many people believe that renewable energy plays an important role in supporting energy security while maintaining the concentration of CO2 emissions. Correspondingly, each 1% increase in the renewable electricity share is followed by a 0.53% decrease in CO2 emission according to Hdom (2019) (Hdom, H. A. D., 2019). Thus, the need to transition away from fossil fuels, at least those burned without carbon capture and storage has been global agenda and takes centre stage.

However, the uncertainty of the energy transition has further widened owing in part to the presence of Covid-19, which has had a significant impact on the world economy. On the one hand, economic recovery must rely on less expensive traditional fossil fuels and the pull of energy-intensive sectors. On the other side, the anti-globalization prompted by Covid-19 has pushed governments throughout the world pay more attention to energy supply security, which will bring up some new development prospects for the renewable energy industry.

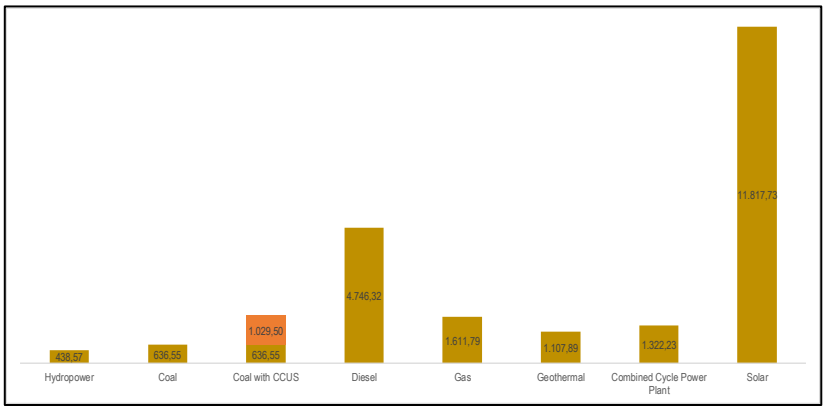

Figure 5. Operating costs of various power plants in Indonesia
Source: PLN Statistics, 2020

Aspects like how the energy markets work, how social acceptance of technology can be improved, political influence (e.g. regulation and taxation), the additional costs that need to be paid by consumers and so on, are all important and should be addressed on energy transition. William Nordhaus, who was awarded the Nobel Prize in economics in 2018, estimated that the costs of transitioning are likely to be so high (Nordhaus, W. D., 2014). Other studies based on more sophisticated energy-economy models are more optimistic, but the estimated costs are still substantial (IEA, 2017; McCollum, D. L., et al, 2018; Grubler, A. et al., 2018; Ram, M., et al., 2019). Although the costs of key renewable energy technologies are likely to continue dropping at their current rapid rates, but still more expensive than fossil-fuel option, without financial assistance.

According to PLN Statistics 2020, coal-fired power has operating costs only higher than hydropower, but lower than other options like solar PV and onshore wind (Fig. 1). Even, with CCUS technology, its cost is still lower than any other options. Indonesia keeps energy prices as affordable as possible through subsidies. Subsides to the energy sector are one of the biggest items on the national budget. The government has a mandate to provide affordable energy supply to the poor, and hence subsidies are designed to be more targeted.

In fact, national Socio Economic Survey published by Indonesia statistics shows that the structure of expenditure distributions between households are vary, depend on income level. The rise in energy prices have a great impact on poverty and energy security, especially within low income groups (poorest 40 percent), who spend a larger proportion of their income on food accounted more than a half of their total expenditure. Meanwhile, top 10 percent households spend around one-third of their total expenditure for food. This means that the energy price increases potentially reduce the real income of poor households, thereby reducing their purchasing power and shifting more of their available income to the purchase of energy. While, for the top 10 percent most likely are able to manage the energy price increases (Indonesia Statistics, author's calculation, 2021).

The additional cost involved during the transition from existing coal based systems, into renewable energy technologies will result in an increase in the cost of basic electricity generation which will be passed on to the price of electricity. And we found that this increase in the actual electricity price during the transition will lead to negatively affect our national economy. Through international agreements and cooperations in both the development of renewable energy technologies as well as financial assistance will mitigate the direct short-term repercussions on the Indonesian economy. Through this an alleviated situation should be achieved.

As is shown in table 6, increasing losses from energy use/own use and from transmission and distribution, and rising electricity generation cost in Indonesia could result in a large reduction in national GDP. A rise in final energy intensity may affect national GDP, but only at a minor level. Meanwhile, improved access to electricity and the use of low-carbon energy might enhance national GDP significantly.

The government thereby needs to make sure that the energy transition effort should not affect peoples' economic position negatively. This especially for those in the lower income bracket who spend the majority of their income on basic necessities.

Indonesia blessed with an abundant volume of coal resources should be capable to utilize this in a preliminary transitioning stage. Because of the possible economic repercussion resulting from a hurried adaption of new renewable energy sources, Indonesia should realize the crucial challenges it still has on reaching that phase. This being the implementation of the neccesary regulation, the development of the next step on technology, the human resources required, and infrastructure as developing renewable energy for Indonesia still needs material which the country does not possess yet, such as the development of advanced wind energy facilities. Within this ecosystem, Indonesia still has to step up to develop the local resources or TKDN which currently stands only at 50% of the utilized components used.

Table 6. Estimation results of the dependent variable: annual GDP

Exogenous Variable	Endogenous Variable		
	GDP (Ln_GDP)		
	Coeffcieint	Stat. Value t	Probability
Energy use/own use loses (SUSUT)	-0.2481***	-5.08	0.001
Transmission and distribution losses (TRANS)	-0.1537***	-7.68	0.000
Access to Electricity (ACCESS)	0.0323***	9.39	0.000
Electricity generation basic cost (Ln_BPP)	0.3986**	-2.36	0.046
Subsidy on Electricity (Ln_SUB)	0.0648**	2.99	0.017
Low-carbon energy per capita (Ln_LEPK)	0.1258*	1.90	0.094
Final energy Intensity (Ln_INTENSITY)	-0.0141	-0.07	0.943
Constant	16.7165	11.47	0.000
	DW stat. = 2.4773		R2 = 0.9982
	VIF = 10.11	Observations 2005-2020	

*** Significant at 1%, ** Significant at 5%, * Significant at 10%,
Source: The regression results of the researcher

While this is being developed from all corners, political, economic, and social, in the mean time, the Indonesian population needs to be provided at all levels with the necessary education to understand the requirement to take these not-always painful steps.

The government now has the important task to guide all in considering the economic impact of adapting renewable energy in all possible instances which now are being resolved through short-term solutions. This through bringing all stakeholders on boards to achieve global cooperation and coordination through enhanced state capacities.

In line with this, Indonesia will need to allocate a serious portion of the national budget to invest in and encourage innovation and technological progress in the field of renewable energy. This with the goals of encouraging new players to take part in the industry and become the main driving force for its development and eventually lead to strong economic growth. Intellectual property protection should be part of this ecosystem so all participants will be contributed and rewarded for their economic contribution.

In the education components of the transition, people should be told the story of the impact from the continued use of fossil fuels. In the fields of employment, education should be the guide to the adoption of the new energy technology. So from a fossil fuel based economy, an organic transition into an environmentally prioritized driven economy, should be achieved.

On the back of the pandemic we have been going through in the past two years, we have seen a real demonstration that the economic deterioration we have been going through in the previous decade is not a done deal. This as within two months after a nationally implemented lockdown, we could observe the reverse environmental effect of our age long continous pollution. That should give us a reason to approach the entire problem of pollution with a positive mindset, and not a defeatist one.

As demonstrated, we cannot rely on fossil fuels. Aside from the fact that soon or later we will run out of these, but even before that happens, we might pollute our environment to such a stage that it might be beyond recovery. So, now is the chance to start our energy transition. But this not focused on the maintaining of the accepted GDP but focused on personal well-being. This can be accomplished by making our planet a safe place to live in, by providing the space to grow abundant food, maintaining clean water, and the provision of the necessary skills for all as required to achieve this.

Developed nations which have achieved their status of development over the past hundreds of years at the expense of the planet's environment should accept their historic responsibility. They have achieved a huge financial benefit and capital gain by exploiting natural resources and the environment.

We have to realize that we still leave the same people in charge of our planet with the same outcome while we are hoping for urgent positive environmental impact. As it so clearly expressed in the identification of the different world economies, 'The Developed Nations', according to their name, should act as such, 'Developed' and take their claim seriously, and not throw it to the developing countries. As opposed to them feeling the need for endless accumulation of military hardware, at a rate of trillions of dollars. This would be far more effectively used by investing these funds into world changing technologies for a clean energy development transition. As an example for this transitionary period, the use of coal should not be halted abruptly. As a transition for the development of using coal, these economies who currently are still blessed by abundant resources and heavily rely on it.

Cutting of coal abruptly for the sake of critical environmental considerations would put these developing countries at an economic disadvantage. Just in order to balance this scale, the developed nations of the world should contribute to their struggle at the rate of what it is they achieved in the past centuries.

According to the above discussions and conclusions, we put forward the following suggestions. First, to better utilize renewable energy resources, it is necessary to systematically evaluate Indonesia's energy endowment and coordinate the relationship between the renewable energy development and national land planning. The development of renewable energy also needs to fully consider the feasibility of planning. The government should scientifically demonstrate the development goals and principal task based on renewable energy resource endowment.

Second, it is essential to promote cooperation among universities and scientific research institutions, local and abroad, and encourage innovation and the technological progress in the utilization of the renewable energy development. An environment with intellectual property protection will promote the extension of the renewable energy industry chain, making new industries the main driving force for economic growth.

Finally, the government should fully consider everyones' participation in Indonesia's economy and its road to developing the renewable energy based partnerships at all levels.

The energy transition will be required if we are to flourish as a people, rather than simply survive, on this planet of ours. We only have one. Only renewed international cooperation and coordination of all state capabilities – a new social contract underwritten by global consensus –can make us prepared, to untangle the current interlocking crises.

CONCLUSIONS AND RECOMMENDATIONS

The following are the conclusions reached as a result of the research. First, from 1970 to 2020, Indonesia's economic activities caused very high environmental degradation. Second, the risk of environmental deterioration from Indonesia's economic activities is decreasing, which is in keeping with the momentum of the 1945 Constitution Article 33 amendment. Third conclusion, the energy sector is an input for other economic sectors, transforming the energy sector from brown to green energy is critical to attaining national low-carbon development. Finally, coal development processing to cleaner environment impact is an alternative solution in the early stages of energy transition in Indonesia. The carbon tax policy could be used to help energy transition especially inf financing energy transition to lower carbon emission. Government should also design incentive for the private sector to develop greener economic activity.

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