The Effect of New Renewable Energy Consumption, Gross Domestic Product, on CO2 Emissions through Green Investment as moderating in the Face of Climate Change

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Abstract. Climate change is a fundamental issue that impacts extinction. On the other hand, in the 2016 Paris Agreement, Indonesia targets a 29% reduction in carbon dioxide (CO2) emissions by its own efforts (CM1) by 2030. Meanwhile, in that year, Indonesia's emissions are estimated to reach 2,869 million tons of CO2. Therefore, the utilisation of new and renewable energy (EBT) can accelerate and become a major contributor in reducing emissions. However, the problem of cost and minimal investment is an obstacle in the utilization of EBT. This study aims to determine the effect of new renewable energy consumption, and GDP on Co2 emissions through green investment as a moderator, using quantitative methods. The results showed that new renewable energy consumption, GDP had an effect, and green investment was able to moderate CO2 emissions in Indonesia.

Keywords: CO2 Emissions, Climate Change, Indonesia, Green Investment, Renewable Energy

1 Introduction

Climate change poses one of the most critical socio-ecological challenges for our time, impacting various aspects of society including ecology, politics, economics, media and social structures.[1] The heavy reliance on fossil fuel-based energy systems like coal, oil, and gas is a primary driver of this phenomenon.[2] In response,

[1] Brulle RJ, Dunlap RE (2015). Sociology and climate change: A synthetic review. Current Sociology, 63(4), 551-571.

[2] Urry J (2011). Climate change and society. Polity Press.

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international collaboration, exemplified by initiatives like the Paris Agreement, aims to limit global warming to less than 1.5 degrees Celsius above pre-industrial levels.

Carbon emissions play a central role in driving climate change, causing widespread effects on environment, health, and the economy.[3] These consequences disrupt human well-being and global economic activities. Despite efforts, carbon emissions continue to rise annually, leading to negative outcomes such as air pollution and rising global temperatures.[4] Addressing these challenges requires collective action from all stakeholders, recognizing air as a shared resource essential for life.[5]

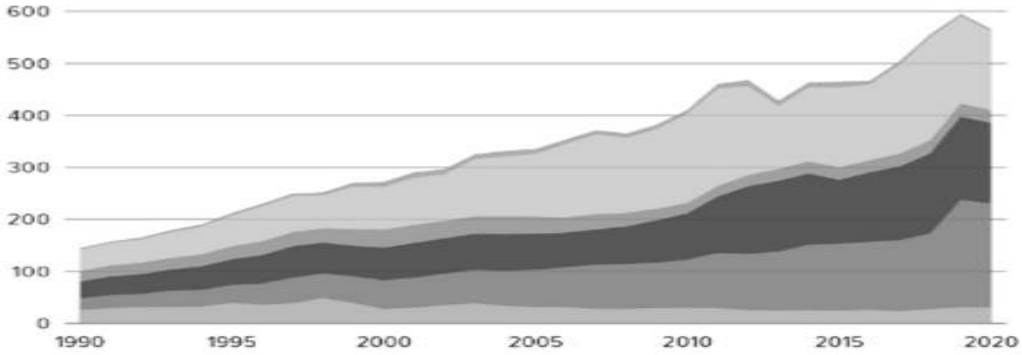

Fig 1. Co2 Emissions by Sector
Source: Indonesia Energy Transtition Outlook, 2022

The primary source of greenhouse gas (GHG) emissions globally stems from CO2 emissions generated through fuel combustion. In Indonesia, emissions have notably surged since 1990, reaching a peak of 620 MtCO2 in 2018. The electricity generation sector is the largest contributor, accounting for 35%, followed closely by transport and industry, each at 27%. Therefore, a pivotal aspect of addressing climate change involves thoroughly reassessing and reimagining our energy systems.[6]

Efforts to combat climate change and energy issues have predominantly focused on reducing carbon emissions. However, a nation's financial progress serves as a key driver for various activities, including banking and both foreign and domestic investments. A well-established financial system facilitates capital access, fostering

[3] Qotrunnada R (2022). Carbon Emissions: Causes, Impacts, and How to Reduce Them. lindungihutan. [https://lindungihutan.com/blog/emisi karbon/]

[4] Marron D, Todd E, Austin L (2015). Taxing Carbon: What, Why, and How. Tax Policy Center. [https://www.taxpolicycenter.org/publications/taxing-carbon-what-why andhow/full]

[5] Ratnawati D (2016). Carbon Tax as an Alternative Policy to Address the Negative Externalities of Carbon Emissions in Indonesia. Journal of Treasury, State Finance, and Public Policy, 1(2), 53-67.

[6] Saud, Muhammad & Mashud, Musta'in & Ida, Rachmah. (2020). Usage of social media during the pandemic: Seeking support and awareness about COVID-19 through social media platforms. Journal of Public Affairs. 20. e02417. 10.1002/pa.2417

improvements in living standards and economic growth, albeit potentially leading to increased GHG emissions.[7]

Nevertheless, financial development doesn't always translate into negative environmental impacts; it can also yield positive results. Ample capital availability and an efficient financial infrastructure empower nations to invest in advanced, eco-friendly technologies, thereby mitigating environmental harm. Furthermore, financial advancement attracts interest from foreign financial and investment sectors capable of transferring eco-friendly technologies to recipient countries. This influx of affordable technologies incentivizes consumers to adopt energy-efficient sources also stimulates investments in environmentally sustainable projects.[8]

Currently, work on climate change and energy futures has been conducted primarily by engineers and economists. This work has produced various engineering- economic models, but has tended to ignore the various social and political forces that support or hinder energy transitions and alternative climate future pathways.[9]

Indonesia has set a goal to achieve a 23% share of renewable energy in its energy mix by 2025, with recent signs indicating a strong inclination towards greater reliance on renewable sources. The Indonesia Electricity Development General Plan (RUPTL) for 2021-2030, unveiled in October 2021, has significantly raised the renewable energy target to 51.6% of the energy mix by 2030, up from the previous plan's 30%. This marks a notable milestone as it exceeds the projected share of fossil fuels, expected to reach 48.4% by 2030.[10]

In addition to transitioning towards renewable energy consumption, investing in projects of sustainable is crucial for advancing sustainability. Many countries are directing investments towards green initiatives to shift towards renewable energy sources and meet energy needs sustainably. These transitions facilitate sustainable development by necessitating financial support for green technologies. However, transitioning poses significant challenges for developing nations, where risks are amplified due to factors like regulatory constraints, limited government support, high investment costs, and energy poverty. Nevertheless, prioritizing green investments and embracing cutting-edge technologies for renewable energy are aligned with the Sustainable Development Goals (SDGs), as highlighted in the SDG progress report.[11]

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[7] Saud, H., & Chen, R. (2018). The Effect of Competency-Based Education on Medical and Nursing Students' Academic Performance, Technical Skill Development, and Overall Satisfaction and Preparedness for Future Practice: An Integrative Literature Review. *International Journal of Health Sciences Education*.

[8] Tamazian, Artur & Piñeiro, Juan & Vadlamannati, Krishna. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. Energy Policy. 37. 246-253. 10.1016/j.enpol.2008.08.025..

[9] Ibid. Urry 2016

[10] https://fiskal.kemenkeu.go.id/nda_gcf/en/publications/indonesia-s-commitment-on-climate-change-amidst-the- covid-19-pandemic

[11] https://fiskal.kemenkeu.go.id/nda_gcf/en/publications/indonesia-s-commitment-on-climate-change-amidst-the-covid-19-pandemic

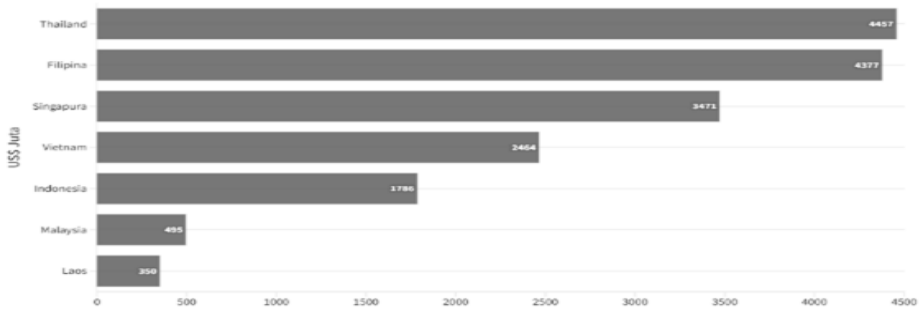

Fig 2. Green Investment in ASEAN
Source: Data Indonesia, 2022

However, according to a report by Bain and Company, the value of green investment in Southeast Asia reached US$17.4 billion in 2020-2022. During these three years, the value of green investment in Southeast Asia continued to decline. This is because investors highlighted various challenges in green investment in the region. These include high capital costs, market access, insufficient returns on investment, and uncertainty over policy direction. Meanwhile, Thailand became the country that received the most green investment in Southeast Asia in 2020-2022. The total green investment agreement in the White Elephant Country reached US$4.46 billion. The second position is occupied by the Philippines with a green investment deal value of US$4.38 billion. Then, Singapore and Vietnam won US$3.47 billion and US$2.46 billion of green investment respectively. Indonesia came in fifth because it received US$1.79 billion in green investment. Then, Malaysia won US$495 million worth of green investment. Laos is at the bottom of the list. The green investment received by the Land of a Million Elephants is around US$350 million throughout 2020-2022.

2 Literature Review

2.1 Orthodox Economic Perspective Theory

The neoclassical economic theory of the environment and natural resources is built upon three fundamental pillars: Individual preferences and subjective judgments are central to this theory. It posits that individuals make decisions based on their preferences and subjective evaluations of the value of goods consumption and the utilization of production factors. Key concepts like marginal utility and subjective cost are pivotal in this regard. Technology constitutes another crucial element. It encompasses the methods and processes utilized to convert inputs into outputs. Technological advancements are deemed significant factors influencing economic decision-making and resource allocation. The market mechanism serves as an essential component of neoclassical economics. It relies on the interplay of supply and demand forces to distribute limited resources among various uses. Through market interactions, individual preferences translate into economic choices, and resources are efficiently allocated to fulfill those preferences. A concept of external economics, as well as the concepts of public goods and free goods, are crucial in the interpretation of the failure of market mechanisms to protect the environment and natural resources. Therefore, state regulatory measures are proposed, to address

market failures so that effective and sustainable use of natural resources and the environment can be achieved.

2.2 CO2 Emissions

Ratnawati (2016) states that carbon emissions are the total amount of carbon dioxide (CO2) released by a person or group of people in a certain period of time, which is measured in tons of CO2 (tCO2e) or kilograms of CO2 (kgCO2e). According to Zhang et al. (2008)[12], carbon emissions consistently increased after the industrial revolution in 1751. The resulting carbon emissions come from two types of resources: fossil fuels (e.g., coal, natural gas, and diesel), which are known as primary energy, and electricity, which is known as secondary energy. There are three drivers of CO2 emissions: output volume, production capacity, and technology.[13] In Indonesia, most of the electricity generated and transmitted to the industrial sector comes from fuels such as coal, natural gas, and oil, which account for around 88% of total fuel consumption. This indicates that the electricity generated is a type of energy that is not environmentally friendly and has an impact on climate change.

2.3 Green Investment

Green investment refers to funds invested to reduce greenhouse gas and pollutant emissions without substantially disrupting the production and consumption of non-energy goods.[14] Green investment is practically considered spending by organisations or companies to have a positive impact on the environment.[15] Green investment is usually realised by companies in the form of environmentally friendly machines and technologies in order to reduce the CO2 emissions produced and reduce energy consumption that is not environmentally friendly (Rokhmawati, 2021),[16] thus reducing the level of greenhouse gas emissions, which ultimately minimises climate change and develops environmental sustainability.[17] Gielen et al. (2019) also stated that green technology will improve or provide alternatives for energy efficiency and can assist in green transformation.[18] Indonesia confronts hurdles in advancing green investment despite the directives set forth in Presidential Regulation Number 16 of 2012 concerning General Investment Plans (UU/16/12),

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[12]Lei Zhang, AaronGL Fletcher, Vanessa Cheung, Fred Winston & LaurieA. Stargell (2008) Spn1Me ngatur Perekrutan Spt6 dan Kompleks Swi/Snf selama Aktivasi Transkripsional oleh RNA Polimerase II, Biologi Molekuler dan Seluler, 28:4, 1393 -1403, DOI:10.1128/MCB.01733-07

[13]Ratnawati D (2016b). Carbon Tax as an Alternative Policy to Address the Negative Externalities of Carbon Emissions in Indonesia. Journal of Treasury, State Finance, and Public Policy, 1(2), 53-67.

[14]Eyraud, L., et, al (2013). Green investment: Trends and determinants. *Energy Policy, 60*, 852–865.

[15]Doval E, Negulescu O (2014). A Model of Green Investments Approach. Procedia Economics and Finance, 15(14), 847-852.]

[16]Rokhmawati, A. (2020). The nexus between type of energy consumed, CO2 emissions, and carbon-related costs. *International Journal of Energy Economics and Policy, 10*(4), 172–183.

[17]Hieu VM (2022). Influence of Green Investment, Environmental Tax and Sustainable Environment: Evidence from ASEAN Countries. International Journal of Energy Economics and Policy, 12(3), 227-235. [https://doi.org/10.32479/ijeep.13028] (https://doi.org/10.32479/ijeep.13028)

[18]Gielen D, Boshell F, Saygin D, Bazilian MD, Wagner N, Gorini R (2019). The role of renewable energy in the global energy transformation. Energy Strategy Review, 24, 38-50.

Article 2 letter d, Section 4, which underscores the importance of environmentally friendly or green investment strategies. As outlined by the Ministry of Industry of Indonesia, green investment necessitates adherence to specific guidelines:

1. Integration of eco-friendly raw materials.
2. Utilization of raw materials with minimal environmental impact.
3. Adoption of principles encompassing reduction, reuse, recycling, and recovery (4Rs).
4. Deployment of energy-efficient technologies.
5. Ensuring that human resources possess expertise in their respective fields and possess environmental awareness relevant to available resources.
6. Implementation of water conservation practices while adhering to ecological quality standards.
7. Embracement of low-carbon technologies.
8. Utilization of alternative energy sources.

Nevertheless, Indonesia faces challenges in amplifying green investment initiatives, primarily due to its substantial reliance on non-green investments.[19]

2.4 Gross Domestic Product (GDP)

Gross Domestic Product (GDP) represents the total value of goods and services produced within a country's borders within a specified time frame, typically a year.[20] Several statements explain the influence of human activities that can have an impact on environmental damage through specific aspects, one of which is financial development.[21] According to Zaidi (2019) and Shahbaz (2013)[22], financial progress and greater trade openness have led to a reduction in carbon dioxide (CO2) emissions. This progress encourages companies to integrate environmental friendly technologies into their production processes, ensuring that their activities and products have minimal environmental impact.

2.5 New Renewable Energy Consumption

Renewable energy stands out as a highly viable solution for addressing environmental degradation and fostering sustainability within society.[23] Zafar et al.

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[19]Muhammad Aviv Adhitya Putra Pratama, Anis Septiana. (2022). Urgensi Gagasan Kebijakan Transfer Fiskal Berbasis Ekologi Di Provinsi Lampung. *Prosiding Seminar Nasional Ilmu Lingkungan (SNaIL)*, *2*(1), 149–161. Retrieved from: https://prosiding.pascasarjana.unila.ac.id/index.php/ProSNaIL/article/view/20

[20]Sukirno, S. (2006). *Development Economics: Process, Problems, and Policy Basis*. Jakarta: Kencana.

[21]Bui, T., Tsai, F. M., Tseng, M., Tan, R. R., Yu, K. D. S., & Lim, M. K. (2021). Sustainable supply chain management towards disruption and organizational ambidexterity: A data driven analysis. *Produksi dan Konsumsi Berkelanjutan*, *26*, 373-410. https://doi.org/10.1016/j.spc.2020.09.017

[22]Zaidi, S. (2019). Dynamic linkages between globalization, financial development and carbon emissions: Evidence from Asia Pacific Economic Cooperation countries. *Jurnal Produksi Bersih*, *228*, 533-543. https://doi.org/10.1016/j.jclepro.2019.04.210

[23]Khattak H, Malhas R, et al (2022) doi: 10.1093/humupd/dmac003. Erratum in: Hum Reprod Update. 2022 Mar 14;: PMID: 35199164; PMCID: PMC9733829.

(2019) also observed that placing greater emphasis on renewable energy and implementing environmental policies contribute to economic growth and enhanced energy efficiency.[24] As per a report jointly published by the International Energy Agency (IEA) and the Organisation for Economic Co-operation and Development (OECD) in 2018, renewable energy consumption is projected to surge by approximately 60% by 2040. Another source cited is Sadorsky (2011).[25] In order to achieve a clean and environmentally friendly environment, 50-80% of the total energy is expected to come from renewable energy. Previous research has investigated the relationship between renewable energy and its environmental sustainability. Bhattacharya et al. (2017) studied the association between renewable energy (REC) use and institutional CO2 emission levels in 84 countries. They used the generalized method of moments (GMM) and fully modified ordinary least squares (FMOLS) estimation methods. Their findings suggest that the use of renewable energy can play an important role in reducing carbon dioxide emissions and improving environmental quality.[26]

Balsalobre-Llorente et al. (2019) analyzed the impact of natural resources on renewable energy, trade liberalization, gross domestic product (GDP) and carbon emissions in five European countries.[27] The findings of this research indicate that utilizing renewable natural resources contributes positively to enhancing environmental quality, whereas the growth of GDP and business activities may lead to increased carbon emissions. Conversely, studies conducted by Hao et al. (2021) and Khan et al. (2020) explored the correlation between the utilization of renewable energy (REC) and environmental quality across G7 member countries. Their results suggest that the adoption of green energy positively influences the enhancement of environmental quality.[28] Additional studies (Bao and Xu, 2019; Charfeddine and Kahia, 2019; Rahman and Velayutham, 2020; Uzar, 2020; Khan and Hou, 2021) also indicate a global trend towards transitioning the industrial structure to a sustainable

[24] Zafar, M. W., et,al, (2019). From non-renewable to renewable energy and its impact on economic growth: The role of research & development expenditures in Asia-Pacific Economic Cooperation countries. *Journal of Clean Production, 212*, 1166–1178.

[25] Sadorsky, P. (2011). Financial development and energy consumption in Central and Eastern European frontier economies. *Kebijakan Energi*, *39*(2), 999-1006. https://doi.org/10.1016/j.enpol.2010.11.034

[26] Bhattacharya, K. (2017). *Dasar-dasar penelitian kualitatif: Panduan praktis.* Grup Routledge/Taylor & Francis. https://doi.org/10.4324/9781315231747

[27] Balsalobre-Lorente, D., et al. (2019). Effect of natural resources, renewable energy and economic development on CO2 emissions in BRICS countries. *Ilmu Lingkungan Total*, *678*, 632–638.

[28] Chen, Pengyu & Hao, Yuanyuan. (2022). Digital transformation and corporate environmental performance: The moderating role of board characteristics. Corporate Social Responsibility and Environmental Management. 29. 10.1002/csr.2324.

and environmentally friendly economy. This transition holds promise for enhancing overall environmental quality. Consequently, an analysis of the literature underscores that reliance on fossil energy sources tends to increase CO2 emissions, whereas the adoption of renewable energy is instrumental in mitigating CO2 emission levels.[29]

3 Research Methods

This study utilizes quantitative research methodology, which is rooted in the positivist philosophy. It entails gathering data from particular populations or samples through quantitative or statistical the instruments.[30] Quantitative research methods are used to test predetermined hypotheses, employing numerical data obtained through measurements of variables on a scale. These data undergo statistical analysis to investigate hypothesized relationships between variables. Moderated Regression Analysis (MRA) is applied to assess how independent variables interact with a moderating variable, potentially either enhancing or attenuating their relationship with the dependent variable.

Sugiyono defines moderator variables as those that impact the relationship between dependent and independent variables, influencing their strength or direction. Likewise, Rayes (2017) suggests that moderation takes place when a third variable alters the relationship between two correlated variables.[31] In summary, moderator variables play an important role in influencing and modifying the relationship between the dependent and independent variables. A moderating effect occurs when a third variable affects the relationship between the other two variables. The data for this study are secondary and obtained indirectly from various literature such as books, journals and research results related to the subject. The data focuses primarily on the use of new renewable resources.This research focuses on Indonesia by looking at the level of RE consumption, Gross Domestic Product (GDP) on CO2 Emissions with Green Investment as a moderating variable in 1990-2021. Data obtained through the World Bank, Our World in Data, Central Bureau of Statistics. With variables of RE consumption (X1), GDP (X2), CO2 Emissions (Y), and Green Investment (Z).

4 Result and Discussion

4.1 Statistical Descriptive Analysis

Descriptive analysis is a statistical tool that functions as a description of the variables in the study. Descriptive analysis is utilized to provide insights into the status or

[29]Sheraz, M., Deyi, X., Mumtaz, MZ *dkk.* Menjelajahi hubungan dinamis antara pembangunan keuangan, energi terbarukan, dan emisi karbon: Sebuah bukti baru dari negara-negara Belt and Road. *Res Pencemaran Sains Lingkungan* 29, 14930–14947 (2022). https://doi.org/10.1007/s11356-021-16641-0

[30]Sugiyono (2017). Quantitative, Qualitative, and R&D Research Methods. Bandung: Alfabeta.

[31] Apriani, Intan & Arabia, Teti & Sufardi, Sufardi. (2019). 1dentifikasi Mineral Tanah dengan Menggunakan Difraksi Sinar-X pada Inceptisol Aceh Besar. Jurnal Ilmiah Mahasiswa Pertanian. 4. 155-163. 10.17969/jimfp.v4i3.11529.

attributes of the dependent variable. Namely Co2 emissions, however, the results of information on descriptive analysis cannot be used as a conclusion on the formulation of the problem.

Table 1. Descriptive Statistics

	X1	X2	Z	Y	X1Z	X2Z
Mean	24903373	4.88E+11	9.502566	3.73E+08	2.32E+08	5.05E+12
Median	20293962	2.86E+11	9.629579	3.47E+08	2.11E+08	3.25E+12
Maximum	1.23E+08	1.12E+12	13.98350	6.59E+08	7.48E+08	1.27E+13
Minimum	2356487.	9.54E+10	6.068343	1.45E+08	21124304	6.46E+11
Std. Dev.	22086427	3.66E+11	2.221098	1.46E+08	1.71E+08	4.18E+12
Skewness	3.162553	0.481382	0.053771	0.311154	1.469649	0.510783
Kurtosis	14.14470	1.535886	2.006174	1.902921	5.079795	1.666876
Jarque-Bera	212.1063	3.966121	1.290704	2.054846	16.74649	3.643557
Probability	0.000000	0.137647	0.524478	0.357928	0.000231	0.161738
Sum	7.72E+08	1.51E+13	294.5796	1.16E+10	7.18E+09	1.56E+14
Sum Sq. Dev.	1.46E+16	4.01E+24	147.9982	6.42E+17	8.76E+17	5.25E+26
Observations	31	31	31	31	31	31

Source: Eviews 10

4.2 Classical Assumption Test

To get a good regression, the data model must be normally distributed and there are no linearity, multicolonierity, autocorrelation and heteroscedasticity problems tested by the classical assumption test.

Table 2. Classical Assumption Test Results

Assumption	Test	Criteria	Results
Normality	Kolmogorov-Smirnov Test	Sig. = 0,3895 > 0,05	Fulfilled
Multicollinearity	Variant Inflation Factor	VIF X1 = 1.129 < 10 VIF X2 = 1.141 < 10 VIF Z = 1.142 < 10	Fulfilled
Heteroscedasticity	Harvey	Sig. = 0.625 > 0,05	Fulfilled
Linearity	Ramsey	Sig. = 0.4547 > 0,05	Fulfilled
Autocorrelation	Durbin Watson	Sig. = 0.8219 (between -2 and +2)	Fulfilled

The classical assumption test can be seen from table 9, which includes a normality test using the Kolmogorov Smirnov test which shows that the residuals have a normal distributionThe evaluation of multicollinearity includes analyzing the variance inflation factor (VIF), where a value below 10 suggests no multicollinearity concerns. The heteroscedasticity assessment, carried out via the Harvey test, signifies the absence of heteroscedasticity issues in the model. Additionally, the examination for autocorrelation, utilizing the Durbin Watson test, indicates no autocorrelation within the model.

Statistical Test

Statistical test is a procedure used to test the results of a hypothesis whether it is accepted or rejected statistically. Statistical tests in this study used the Eviews 10 programme.

Test t (Partial Test)

The t test aims to determine and measure the effect of independent variables on the dependent variable partially. In table 3**.** Renewable energy consumption variables (X1), GDP (X2), Co2 emissions (Y), and Green Investment (Z).

Table 3. Partial Test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	91791141	26396114	3.477449	0.0017
X1	-0.286177	0.249937	-1.145000	0.2623
X2	0.000347	1.77E-05	19.60939	0.0000
Z	12540026	2924978.	4.287220	0.0002

Source: Output eviews 10 for windows

Test of Simultaneous (F Test)

The purpose of the F-test is to ascertain the collective impact of independent variables on the dependent variable. The interpretation of the F-test outcomes for the equation has been provided in Table 4.

Table 4. F-Statistic Test

F-statistic	232.1300
Prob(F-statistic)	0.000000

Source: Output eviews 10 for windows

The equation indicates that the results of the F-test in this analysis reveal a prob (F-statistic) of 0.0000, which is below 0.05. Consequently, it can be inferred that the variables namely, renewable energy consumption (X1), GDP (X2), CO2 emissions (Y), and green investment (Z) exert a significant impact.

Model Fit Test (*Goodness of Fits*)

The Goodness of Fits test can be seen from the coefficient of determination, or R- squared value, which represents the model fit test, is displayed in Table 5.

Table 5. Model Fit Test (*Goodness of Fits*)

R-squared	0.962676
Adjusted R-squared	0.958529

Source: Output eviews 10 for windows

The R-squared value indicates a coefficient of determination of 0.958529, implying that approximately 95.85% of the variance in the dependent variable (CO2 emissions, Y) can be accounted for by the independent variables: renewable energy consumption (X1), GDP (X2), and green investment (Z). The

residual variance is attributable to factors not included in this regression model.

Moderated Regression Analysis

Moderated Regression Analysis (MRA) delves into moderating variables through regression model equations employed on panel data. These equations incorporate multiplicative interactions among two or more independent variables.The moderating variable in this study is Green Investment (Z) which will moderate the relationship between the hypothesis of EBT consumption (X1), GDP (X2), Co2 Emissions (Y) in the Moderated Regression Analysis (MRA) test is as follows:

H_0 is rejected	Probability value > α 0.05
	Moderating variables weaken the effect of the independent variable on the dependent variable
H_0 accepted	Probability value < α 0.05
	Moderating variables strengthen the influence of the dependent variable on the dependent variable

If the probability value is greater than α (0.05), the null hypothesis (H0) is rejected, indicating that the control variable weakens the influence of the independent variable on the dependent variable. On the other hand, if the probability value is less than α (0.05), then the null hypothesis (H0) is accepted, which means that the control variables strengthen the relationship between the independent and dependent variables.

Table 6. MRA Interaction Test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.08E+08	15460554	13.47058	0.0000
X1Z	-0.021567	0.050200	-0.429617	0.6708
X2Z	3.36E-05	2.05E-06	16.40355	0.0000

Source: processed 2023, Eviews 10

Based on the outcomes of the moderated regression analysis (MRA) outlined in Table 6, the following conclusions can be drawn:

1. The probability value associated with the interaction between EBT utilization and green investment concerning CO2 emissions is 0.6708, with a significance level (α) of 0.05. Consequently, the null hypothesis (H0) is upheld, suggesting that EBT utilization does not significantly strengthen or weaken the influence of green investment (Z) on carbon dioxide emissions (Y), indicating a quasi- moderating effect.
2. The probability value linked to the interaction between GDP and green investment concerning CO2 emissions is 0.000, which falls below the significance level (α) of 0.05. Consequently, the alternative hypothesis (Ha) is supported, indicating that green investments have a moderating impact on the relationship between GDP and CO2 emissions.

4.3 The Relationship Between Renewable Energy Consumption, CO2 Emissions and Green Investment

Green investments may not be large or significant enough to generate substantial CO2 emission reductions. While green investments are important, if their scale and impact are limited, the consumption of renewable energy may not be able to moderate the effect of CO2 emissions. Although the consumption of renewable energy such as solar, wind or hydroelectric energy is more environmentally friendly than fossil fuels, technological and efficiency factors also need to be considered. If the technology used in renewable energy is not efficient enough or has not reached a mature stage, the impact of emission reduction may not be very large. If non-green energy consumption (such as coal, oil or gas) is still dominant in the energy consumption pattern, the positive impact of RE consumption in moderating green investment may not reach its potential. Government policy and regulatory factors are crucial in encouraging green investment and changing energy consumption patterns. If there are not strong enough incentives or supportive policies, RE consumption may not be able to moderate the CO2 emission effects of green investment. The energy system is a complex network, involving many actors such as producers, consumers, energy companies and governments. Renewable energy consumption may only be one part of this system, and its influence on green investment and CO2 emissions may be more limited due to its complex dynamics. The effects of green investment and renewable energy consumption on CO2 emission reduction may take a longer time to become visible. Investments in renewable energy and green technologies usually take time to yield tangible results.

Investments in renewable energy and green technologies often take time to see tangible results. Green investments, which include climate change, renewable energy, clean technology and other areas, are considered low-carbon or climate-resilient investments.[32] These investments aim to reduce greenhouse gas emissions and air pollutants without significantly reducing the production and consumption of non-energy goods.[33] Practically, green investment is considered as the expenditure of an organisation or company to have a positive impact on the environment (Doval & Negulescu, 2014).[34] Many companies allocate a portion of their profits to invest in green practices, such as environmental monitoring, waste management, renewable energy, and green technology. Green investment is a motivation for companies to compete with competitors who have implemented green measures, with the aim of reducing CO2 emissions and maintaining environmental sustainability.[35] One method to reduce CO2 emissions is to invest in environmentally friendly practices, often referred to as Green Investment.

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[32] Voica, Panait, & Radulescu (2015). Green investments, including climate change, renewable energy, clean technology, and other areas, are considered low-carbon or climate-resilient investments

[33] Eyraud, Clements, & Wane (2013). Green investments aim to reduce greenhouse gas emissions and air pollutants without significantly reducing the production and consumption of non-energy goods.

[34] Doval & Negulescu (2014). Practically, green investment is considered as the expenditure of an organization or company to have a positive impact on the environment

[35] Xu & Lin (2020). The growth of investment in air pollution and environmental treatment in the industrial sector is still low, with limited impact on CO2 emissions.

This finding is in line with research by Xu & Lin (2020),[36] who found that the growth of investment in air pollution and environmental treatment in the industrial sector is still low, with limited impact on CO2 emissions. Many environmentally friendly practices in manufacturing companies in Indonesia are still limited to the management, monitoring, and control of hazardous & non-hazardous waste. In fact, to substantially reduce CO2 emissions, a wider range of environmentally friendly practices are needed, such as reforestation, land conservation, post-mining reclamation, renewable energy sources, Energy Management System (EMS), Environmental Management and Audit, and the use of environmentally friendly technology and machinery.[37]

Therefore, a clear legal basis and substance is needed regarding the "Green Investment" policy. This will provide guidance to manufacturing companies to improve effectiveness and target accuracy in the allocation and realisation of funds for environmentally friendly practices, especially for CO2 emission reduction. The government, as a regulator, should make a clear legal basis and substance, focusing on clean energy investment or green investment, including the addition of environmental regulations for carbon-intensive industries such as manufacturing. The government, as a regulator, should make a clear legal basis and substance, focusing on clean energy investment or green investment, including the addition of environmental regulations for carbon-intensive industries such as manufacturing.[38]

4.4 GDP to Co2 Emissions through Green Investment

Economic growth that occurs as a result of high GDP can encourage companies and industries to improve efficiency in production and consumption. Green investments, such as in clean and environmentally friendly technologies, can be part of the effort to improve efficiency and reduce CO2 emissions. Economic growth can incentivise innovation in cleaner and more efficient technologies. Investments in green technology research and development can lead to new solutions to reduce CO2 emissions and negative environmental impacts. Sustained economic growth is often necessary to support the implementation of stronger environmental policies. An increase in GDP can provide governments with greater resources to pass policies that encourage green investment and reduce CO2 emissions.

Good economic growth can increase the potential for investment in green projects, including renewable energy, sustainable transport, and green infrastructure. An increase in GDP can ensure the availability of sufficient funds for these investments. An increase in GDP can enable countries to make the transition from fossil-based energy sources to renewable energy. Investments in renewable energy and green energy infrastructure can be better financed with higher economic growth. Higher

[36] Xu & Lin (2020). Ibid

[37] Rachman (2018). Environmentally friendly practices in manufacturing companies need to expand beyond waste management to include reforestation, land conservation, post-mining reclamation, and the use of environmentally friendly technology

[38] Shahbaz et al. (2014). A clear legal basis and substance are needed regarding the "Green Investment" policy, providing guidance to manufacturing companies for effective allocation of funds for environmentally friendly practices

economic growth can create greater awareness and demand for green products and services. This can encourage industries to invest in green technologies and practices to meet this demand. Economic growth supported by increased GDP can contribute to human capital capacity building through education and training. This increased capacity can support increased knowledge and awareness of environmental issues, including green investments. Sustainable economic growth can enable countries to build green infrastructure, such as efficient and environmentally friendly public transport networks, which in turn can help reduce CO2 emissions.

Economic Growth is positively and significantly related to Carbon Emissions, as estimated through the relationship between economic growth (GDPCAP) and emissions (CO2CAP) at the 2% level in both the short and long term. In other words, if per capita income increases by 1 US$, carbon emissions are also expected to increase by 1.408788 metric tonnes in the short term and 4.879897 metric tonnes in the long term, assuming other variables remain constant. The model estimation shows a high level of representativeness, with the F-test being significant at the 0% level, and as much as 94.32% of changes in the endogenous variable (GDPCAP) can be explained by changes in the exogenous variables, while 5.68% is explained by variables outside the model. Increased economic growth in Indonesia is believed to increase emissions, mainly due to economic activities that depend on natural resources (SDA), such as plantations, mining, and forestry. In addition, capital-intensive industries with low technology, underdeveloped public transport, and large energy demands that tend to be less efficient are also contributing factors.[39] While this finding differs from the study by Koçak and Şarkgüneşi (2018)[40], it is similar to the findings of Begum et al. (2015)[41] and Ssali et al. (2019).[42] Green infrastructure investment financing, especially between 2004-2011, showed an increasing trend, with an average increase of 26% per year.

Fossil fuels reached $630 billion in 2011, while the world's energy consumption from renewable energy was only $66 billion. Research and technology development in the field of solar panels has also supported the development of green industries, with the price of solar modules falling by 75% since 2008. The global economic recession in 2008 proved that a green economy can create jobs, and some countries, such as China and South Korea, integrated green programmes in their fiscal stimulus. In Indonesia, the government needs to improve the quality of information on employment opportunities and skills related to green growth, while improving the quality of skills

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[39] Priyagus (2023). Economic growth can encourage companies and industries to invest in green projects, including renewable energy, sustainable transport, and green infrastructure

[40] Koçak E, Şarkgüneşi A. "The impact of foreign direct investment on CO2 emissions in Turkey: new evidence from cointegration and bootstrap causality analysis." Environ Sci Pollut Res. 2018;25(1):790–804. DOI: 10.1007/s11356-017-0468-2.

[41] Begum RA, Sohag K, Abdullah SMS, Jaafar M. "CO2 emissions, energy consumption, economic and population growth in Malaysia." Renewable Sustainable Energy Reviews. 2015;41:594–601. DOI: 10.1016/j.rser.2014.07.205

[42] Ssali MW, Du J, Mensah IA, Hongo DO. "Investigating the nexus among environmental pollution, economic growth, energy use, and foreign direct investment in 6 selected sub-Saharan African countries." Environmental Science and Pollution Research. 2019;26:11245-11260. DOI:10.1007/s11356-019-04455-0.

provision in the education system.[43]

Dogaru's research highlights the pivotal role of green growth in attaining sustainable development objectives and advancing social equity. The idea of a green economy entails a fundamental transition towards more efficient, environmentally sustainable, and resource-conserving technologies to mitigate emissions and confront climate change. As a result, green investment has become a fundamental element of the worldwide economy. This concept aligns with global endeavors to pursue green investments, with forecasts indicating that investments spanning from 2020 to 2035 should aim for net-zero global emissions. Hence, collaborative endeavors are imperative to embrace green economic strategies that bolster human welfare, social equity, and environmental preservation, while also prioritizing resource efficiency and conservation.[44]

5 Conclusions and Recommendations

The study demonstrates the intricate interplay among renewable energy utilization, GDP, CO2 emissions, and green investment as drivers in combating climate change. Findings reveal that while renewable energy usage can mitigate carbon dioxide emissions, its impact is overshadowed by economic growth, as measured by GDP. However, green investments have emerged as pivotal in offsetting the adverse effects of GDP on energy consumption and carbon emissions. These findings underscore the significance of sustainable investment initiatives in facilitating the transition towards a low-carbon economy. As part of the climate change mitigation efforts, a crucial recommendation is to harmonize economic growth with endeavors to curtail carbon emissions. Collaboration between government and industry is essential to devise policies that promote increased adoption of renewable energy sources without neglecting economic growth. Green investment stands as a vital avenue to achieve this equilibrium, with channeling funds into environmental conservation projects mitigating the adverse environmental impacts of economic growth. Hence, cross-sectoral cooperation is imperative to formulate comprehensive and sustainable measures to effectively address the challenges posed by climate change.

Drawing from the study's outcomes, several conclusions can be drawn. Firstly, governments and relevant entities need to enact policies that incentivize the utilization of renewable energy sources as integral components of economic strategies. Support mechanisms such as incentives, tax credits, and voluntary regulations can incentivize businesses and local communities to transition towards cleaner and sustainable energy sources. Moreover, ramping up investment in research and development of renewable energy technologies can help overcome technical barriers, thereby expediting the widespread adoption of renewable energy sources. Secondly, there is a need to bolster the regulatory role of green investment through

[43] Priyagus (2023). Economic growth can encourage companies and industries to invest in green projects, including renewable energy, sustainable transport, and green infrastructure

[44] Dogaru (2021). Green growth is of key importance for achieving the goals of sustainable development and social justice, requiring joint efforts to adopt green economic policies.

collaborative efforts between the public and private sectors. Governments can foster an enabling environment for green investment by offering financial incentives and support mechanisms. Conversely, industry stakeholders must factor in environmental and social considerations when making investment decisions. Collaborative endeavors between sectors can spur the development of innovative green projects and contribute positively to carbon emission reduction. Enhanced awareness and transparent reporting on the environmental impacts of investments are also pivotal in fostering public trust and enhancing accountability in addressing the climate change challenge.

The findings indicate that investing in renewable energy does not directly decrease carbon emissions from new energy consumption. However, it does contribute to reducing the carbon intensity of Gross Domestic Product (GDP). This study underscores the intricate relationship among these variables, emphasizing the necessity of ongoing investment efforts aimed at facilitating the transition to a low-carbon economy. Addressing climate change requires aligning endeavors to reduce carbon emissions with economic growth. Therefore, collaboration between government and industry is imperative to devise policies that promote renewable energy adoption. Green investments serve as a crucial tool in striking this balance without compromising sustainable economic development. Channeling resources into green projects can mitigate the adverse environmental impacts of economic progress. Hence, cross-sector collaboration is pivotal in formulating comprehensive and resilient responses to effectively tackle the climate change challenge.

Sustainable green investments play a pivotal role in safeguarding environmental well-being and curbing degradation. By investing in renewable energy, we can reduce our carbon footprint and create a healthier, more sustainable world for future generations. However, before raising funds, thorough research is essential to ensure that investments positively impact both people and nature. The beneficial effects of energy efficiency on environmental sustainability are evident in both short-term and long-term assessments. Implementing energy-efficient measures can enhance environmental quality by curbing carbon emissions and minimizing environmental impact. The report highlights Indonesia as the third-ranked country in terms of the highest employment potential in the green economy. Allocating 2% of its national income to the green economy could potentially create 4.4 million to 6.3 million new jobs within five years, following the examples of the United States and Brazil. It's important to acknowledge that a 2% investment may not be fully supported by substantial capital alone. Thus, government collaboration with the private sector is crucial. Green job opportunities encompass various sectors, including waste management, recycling, organic farming, and the manufacturing of solar panels and other environmentally friendly products.

Firstly, governments and relevant institutions should devise policies to incentivize renewable energy utilization as part of economic development strategies. Support measures such as tax incentives and environmental regulations can encourage industries and societal actors to transition towards cleaner, more sustainable energy sources. Secondly, to overcome technical barriers and accelerate the widespread adoption of renewable energy, increased investment in research and development of

renewable energy technology is imperative. The significance of green investment as a mitigating factor should be reinforced through public-private partnerships. The government can promote green investment through attractive tax and fiscal incentives, while industry players should consider environmental and social factors in investment decisions. Collaborative partnerships across sectors can drive the development of innovative environmental projects that positively impact carbon emission reduction. Enhanced transparency and reporting on the environmental impact of investments can foster public trust and bolster our collective responsibility to combat climate change.

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[14]https://fiskal.kemenkeu.go.id/nda_gcf/en/publications/indonesia-s-commitment-on-climate-change-amidst-the-covid-19-pandemic

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