ENERGY TRANSITION IN ASEAN–6: EMPIRICAL EVIDENCE ON THE IMPACT OF ECONOMIC GROWTH, CARBON EMISSIONS, AND FOREIGN INVESTMENT

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Abstract

This study analyzes the influence of economic growth, carbon emissions, and Foreign Direct Investment (FDI) on renewable energy consumption in Indonesia, Singapore, Malaysia, Vietnam, the Philippines, and Thailand. The data used is panel data, with the selected model being the Fixed Effect Model (FEM). The results show that economic growth and FDI play a role in driving increased renewable energy consumption, while carbon emissions remain a challenge in the transition to green energy. Overall, economic dynamics, the environment, and foreign investment are closely linked in determining the direction of renewable energy development in this region. Therefore, policies that support investment in green energy, strengthening environmental regulations, and developing renewable energy infrastructure are needed to ensure future energy sustainability.

Keywords: Economic Growth, Carbon Emissions, FDI, Renewable Energy

INTRODUCTION

Through a declaration adopted in September 2015, all Member States of the United Nations agreed on 17 Sustainable Development Goals (SDGs) under the 2030 Agenda for Sustainable Development (Nations, 2019), covering the most critical issues faced by humanity. Among the 17 SDGs, SDG 7—"Ensure access to affordable, reliable, sustainable, and modern energy for all"—plays a crucial role. Monitoring and evaluating progress toward SDG 7 is essential for designing energy strategies and policies (Zhao et al., 2025). Current global developments indicate that renewable energy has become a primary focus in efforts to achieve sustainable economic growth and address the climate change crisis (Tiep et al., 2020). Particularly for developing regions such as ASEAN, implementing SDG 7 is both a challenge and an opportunity, given high energy demand, dependence on fossil fuels, and the vast yet underutilized potential of renewable energy (Jayachandran et al., 2022).

ASEAN, as one of the fastest-growing economic regions in the world, faces major challenges in meeting continuously increasing energy demand while reducing carbon emissions (Sugiharti et al., 2025; Tang et al., 2024). According to Yang & Lo, (2024) , the growing renewable energy industry, as part of the green market, offers a new economic growth model capable of reducing the negative impacts of non-renewable energy consumption while promoting sustainable development techniques. A key way to assess how prepared countries are for a sustainable energy transition is by examining the amount of renewable energy they use.

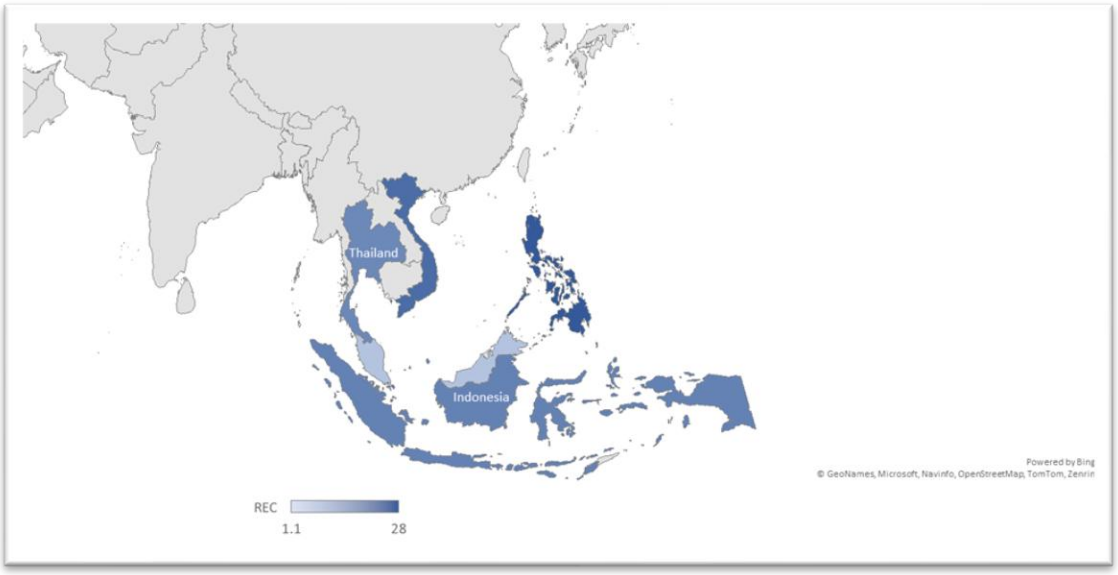

Figure 1.
Renewable Energy Consumption in the ASEAN-6 Region
Source: World Bank, processed data (2026)

Figure 1 shows that Vietnam recorded the highest level of renewable energy consumption, primarily due to its massive expansion in the solar and wind power sectors. Thailand and Malaysia are in the middle, while Indonesia and the Philippines each remain below 12%. Conversely, Singapore, despite its high income, only recorded consumption of

around 1.1% due to resource and land constraints. This map highlights that despite strong commitments to the energy transition, actual implementation at the national level still faces structural barriers. However, the Institute for Essential Services Reform (2024) noted that the contribution of renewable energy to the total energy mix in ASEAN countries has only reached 15%, still far from the 23% target set in the ASEAN Plan of Action for Energy Cooperation (APAEC) 2025. The achievements of ASEAN-6 countries in renewable energy also show significant variation.

Economic growth is a key indicator influencing increased renewable energy consumption, with numerous studies demonstrating a positive and significant relationship between the two in the long run (Li & Leung, 2021). Increasing GDP indicates increased economic activity in a country (Azzahrah et al., 2024). When pursuing economic growth, emerging industrial economies must consider the urgency of carbon emission reduction and energy transition to address global challenges such as climate change and energy security (Dong et al., 2021). With continued economic growth, developing countries, particularly those in the ASEAN region, are becoming major contributors to global economic growth (Nasir et al., 2019). The ASEAN-6 economic growth is projected to remain stable, with an average GDP growth of 4.3% in 2023 (Asian Development Bank, 2024). This growth opens up significant investment opportunities in the energy sector, but if not properly managed, it also risks increasing fossil-based energy consumption.

The relationship between CO_2 emissions and renewable energy consumption plays a crucial role in Asia's sustainable energy trajectory (Abbasian & Talebi, 2025). The application of renewable energy plays a vital role in reducing emissions and is one of the solutions to achieving the Sustainable Development Goals (SDGs) (Saidi & Omri, 2020). Increasing the use of renewable energy sources—such as solar, wind, and biomass—is a crucial solution to reduce dependence on fossil fuels and lower carbon emissions (Shodrokova et al., 2024). The Climate Action Tracker (2024) report shows that carbon emissions in Indonesia and Vietnam are increasing due to the expansion of the industrial and coal-based energy sectors. Meanwhile, Thailand and Malaysia are beginning to show signs of decarbonization through the integration of clean energy, while Singapore, despite its low absolute emissions, has the highest per capita emissions in the region due to its energy-intensive economic structure. The relationship between CO_2 emissions and renewable energy consumption plays a crucial role in Asia's sustainable energy trajectory (Abbasian & Talebi, 2025). On the other hand, dependence on fossil fuels is driving a surge in carbon emissions, making awareness of the need to shift to clean energy increasingly urgent (Martins et al., 2021). This is reinforced by the findings of Rafindadi & Ozturk (2017) which state that the increase in carbon emissions tends to be inversely proportional to the adoption of renewable energy.

FDI plays a crucial role in supporting renewable energy development, through technology transfer, increased clean generating capacity, and financing of environmentally friendly energy projects. ASEAN has successfully attracted significant foreign investment, increased international trade, and implemented various structural reforms to strengthen its economic competitiveness (Hidayat et al., 2024). FDI is a crucial factor in ASEAN's energy dynamics (Sitthivanh & Srithilat, 2021). ASEAN attracts global investors thanks to its potential for rapid economic growth, strategic location, political stability, pro-investment policy support, regional integration through the ASEAN Economic Community (AEC), and

accelerated infrastructure development (Barat, 2018; Losari & Koesnaidi, 2014). Countries such as Singapore, Malaysia, Indonesia, and Thailand stand out in terms of their investment climate and largest GDP contribution in the region (Fatimah et al., 2024; Hidayat & Shodrokova, 2024). Foreign direct investment has proven crucial for driving economic growth, particularly in developing countries with established financial markets. Research by Nguyen & Bui (2024) shows that FDI incentives combined with strict emissions regulations accelerate the adoption of clean energy technologies in Vietnam and Thailand. However, the attraction of FDI in the renewable energy sector still faces obstacles, ranging from regulatory uncertainty, limited infrastructure, and political risks. As emphasized by Uctum et al. (2023) and Jamaluddin,Widodo & Siregar, (2023), the success of renewable energy development depends not only on FDI but also on domestic readiness, including infrastructure and workforce skills.

Most previous studies tend to discuss the relationship between these two variables separately, while this study examines the interaction of the three simultaneously in six ASEAN countries, each with its own complex development and energy policy. Furthermore, this study positions carbon emissions not only as a consequence of economic growth but also as a potential barrier to the renewable energy transition, a situation not widely addressed in previous studies. This study also pays special attention to the direction of FDI destination sectors, assessing whether foreign investment actually supports clean energy development or reinforces dependence on fossil fuels. With a cross-country approach and adequate timeframe, this research is expected to provide new and in-depth perspectives, contribute to the development of thinking in this field, and enrich the related scientific literature. The research problem formulation in this research is: How do economic growth, carbon emissions, and FDI affect renewable energy in ASEAN-6 countries?

REVIEW OF LITERATURE

The Environmental Kuznets Curve (EKC) was developed by Simon Kuznets in 1955 and explains that at the beginning of economic growth, environmental degradation increases, but after reaching a certain point (turning point), economic growth actually reduces the negative impact on the environment. In the early stages of growth, increasing GDP tends to increase carbon emissions and discourage the use of renewable energy due to dependence on fossil fuels. However, after reaching a certain income level, economic redistribution and environmental awareness increase, ultimately reducing inequality and encouraging the use of environmentally friendly technologies. Research conducted by Udeagha & Ngepah (2023) supports the Environmental Kuznets Curve (EKC) hypothesis, which states that in the early stages of economic growth, CO_2 emissions increase, but decline after the economy reaches a certain level of prosperity. However, energy use and exploitation of natural resources have been shown to significantly contribute to environmental degradation, both in the short and long term (Liu et al. ,2023). Therefore, policies that encourage energy innovation and sustainable investment are needed to achieve green development goals.

Carbon emissions are often associated with low renewable energy consumption in developing countries. The increasing use of fossil fuel-based energy has resulted in many countries producing higher CO2 emissions, resulting in increasingly intense problems related to environmental pollution and global climate change (Raza et al., 2025). High dependence

on fossil fuels as the primary energy source causes carbon emissions to remain high and hinders the development of renewable energy (Pao & Fu, 2013). Several empirical studies have found a negative relationship between carbon emissions and renewable energy use. For example, research by Al-Mulali et al. (2015) shows that increasing carbon emissions in developing countries are associated with low investment in renewable energy. This is due to high fossil fuel subsidies that make renewable energy less cost-competitive. However, several studies also show that global pressure to reduce carbon emissions can encourage developing countries to adopt renewable energy. Research conducted by Dong et al. (2017) found that a country's commitment to international environmental agreements, such as the Paris Agreement, can accelerate the green energy transition despite initially high carbon emission levels. Therefore, stricter environmental policies and reduced fossil fuel subsidies are needed to ensure that high carbon emissions do not hinder the growth of renewable energy (He et al., 2016).

FDI can play a significant role in renewable energy development in developing countries through technology transfer and capital investment (Zhang & Zhou, 2016). According to the FDI-Led Growth Hypothesis, foreign direct investment can bring green technologies that support the transition to renewable energy, especially in countries with favorable environmental regulations. Doytch & Narayan (2016) found a correlation between FDI and energy consumption, indicating a positive impact on renewable energy adoption. This suggests that FDI can be a catalyst in increasing green energy capacity. Research by Shahbaz et al. (2018) shows that the impact of FDI on renewable energy is highly dependent on the environmental policies implemented by developing countries. Countries with strict environmental regulations and incentives for renewable energy tend to attract FDI that supports green energy development, while countries with weak regulations tend to attract FDI that increases fossil fuel consumption.

RESEARCH METHOD

The variables used in this study are renewable energy, economic growth, carbon emissions, and FDI in ASEAN-6 countries: Indonesia, Malaysia, Thailand, the Philippines, Vietnam, and Singapore. These countries were selected due to their significant economic contributions, diverse energy and emissions, high FDI flows, commitment to energy transition, and adequate data availability. This study uses panel data from 1995 to 2024 obtained from the World Development Indicators (WDI). The operationalization of the variables used is further explained in Table 1.

Table 1.
Operational Variables

Variable	Definition	Measurement	Source
Renewable Energy (REC)	Energy derived from natural sources that can be continuously replenished.	Renewable energy consumption (% of total final energy consumption)	WDI

Economic Growth (GDP)	An increase in a country's production capacity and economic output measured through gross domestic product over a certain period.	GDP per capita growth (annual %)	WDI
Carbon Emissions (CO2E)	The release of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere due to human activities, especially from fossil fuel combustion.	Carbon dioxide (CO2) emissions excluding LULUCF per capita (t CO2e/capita)	WDI
Foreign Direct Investment (FDI)	Direct investment by a company or individual from one country into another country.	Foreign direct investment, net (BoP, current US$)	WDI

Source: WDI (2026)

This study uses panel data regression to examine the influence between variables. The panel data regression model used in this study is:

$$REC_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 LNCO2E_{it} + \beta_3 LNFDI_{it} + e_{it}$$

where β is a constant; REC is renewable energy; GDP is economic growth; CO2E is carbon dioxide (CO2) emissions; FDI is foreign direct investment; i is the cross-section; t is the time series; and e is the error term.

This study uses panel data regression with a fixed effects model (FEM). Before estimating the panel data regression model, several tests were conducted, including selecting the best model using the Chow test, the Hausman test, and the Lagrange multiplier test, classical assumption testing, and hypothesis testing.

RESULT AND DISCUSSION

Renewable Energy in ASEAN Countries – 6

According to Figure 2, over the period from 1995 to 2024, significant changes in the share of renewable energy in ASEAN countries such as Indonesia, Vietnam, Thailand, the Philippines, Malaysia, and Singapore are visible. Indonesia and Vietnam recorded very high renewable energy consumption at the beginning of the period. However, along with rapid industrialization and rapid economic growth, these two countries experienced a sharp decline in renewable energy use. This is closely related to the soaring energy demand, which is unfortunately largely met by fossil fuels such as coal and petroleum due to their availability and lower cost. In recent years, renewable energy consumption in these two countries has declined, reflecting the significant challenge of maintaining a balance between economic development and environmental sustainability.

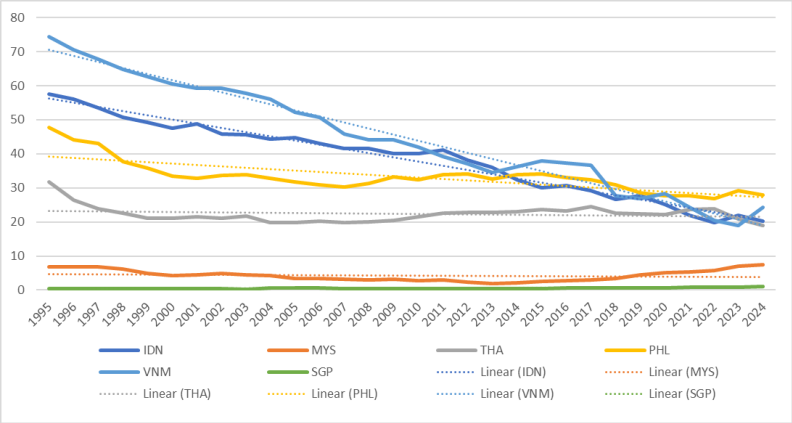

Figure 2.
Renewable Energy Consumption in the ASEAN Region – 6
Source: WDI, processed data (2026)

Meanwhile, Thailand also experienced a decline in renewable energy consumption, but at a more gradual rate. This suggests that despite the transition to fossil fuels, Thailand appears to be more able to maintain some use of clean energy, likely through diversification of energy sources and the development of renewable energy policies. The Philippines is an interesting exception. The country maintained relative stability in its renewable energy use, ranging from 30 to 35% throughout the period. The Philippines has abundant renewable energy resources such as hydropower and geothermal energy, and has implemented a fairly progressive national policy in maintaining green energy. As explained by Koons (2024) in the article Hydropower in the Philippines – Role and Future, hydropower in the Philippines not only contributes significantly to the national energy mix but is also a crucial pillar in achieving sustainable energy targets.

Malaysia and Singapore present different characteristics. Both countries have historically had very low renewable energy shares, below 10 percent. However, since around 2014, there has been a slight increase, in line with growing awareness of climate change and government efforts to expand the use of solar energy and other green solutions. For Singapore, in particular, geographical limitations pose a significant challenge to the development of large-scale renewable energy sources. This is closely related to global and local factors such as economic growth, urbanization, the availability of fossil fuel resources, international pressure following the 2015 Paris Agreement, and changes in national energy policy. Indonesia and Vietnam's dependence on coal, the industrial boom in Malaysia, and Singapore's limited land availability all contribute to the patterns we see. According to a Tempo report, ASEAN countries are now at a critical juncture in accelerating their renewable energy transition to reduce their dependence on fossil fuels, given the increasing global pressures of climate change.

GDP Per Capita in ASEAN Countries – 6

GDP per capita growth in the six main ASEAN countries—Indonesia, Malaysia, Thailand, the Philippines, Vietnam, and Singapore—is shown in Figure 4. In the mid-1990s, all lines in the graph moved in the range of 6 to 8 percent. The situation changed drastically when the Asian financial crisis erupted in 1997-1998, when Indonesia plunged by double

digits to around minus 13 percent, and Malaysia and Thailand by minus 7 percent. Singapore, however, was slightly dragged down, and Vietnam, which was then less integrated into global capital markets, remained positive, albeit at a slower pace. Entering 2000, the graph showed a simultaneous recovery phase, with average growth returning to 4 to 6 percent before gradually leveling off. The global financial crisis of 2008-2009, which pushed almost all growth lines to zero, even reaching negative levels in Singapore, allowed the region to recover relatively quickly. However, a surge in commodity prices and fiscal stimulus enabled the region to recover relatively quickly.

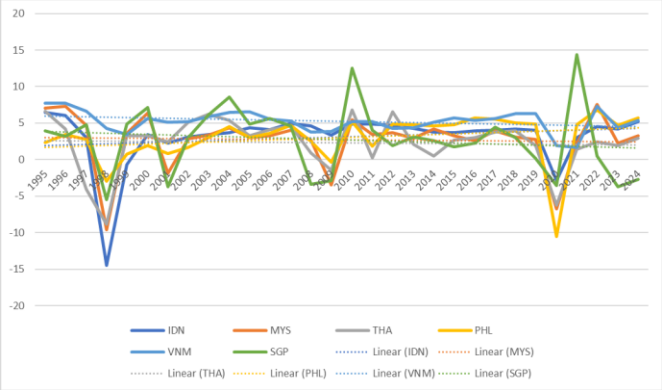

Figure 3.
GDP Per Capita in the ASEAN Region – 6
Source: WDI, processed data (2026)

The next drastic decline occurred in 2020 during the COVID-19 pandemic. In the graph, all countries, especially the Philippines and Thailand, recorded the deepest negative growth due to their dependence on tourism and services. Malaysia was hit by sluggish manufacturing demand, Singapore was pressured by the halt in global trade, while Indonesia withstood the decline thanks to its large domestic market. Vietnam again demonstrated its resilience; its growth was barely flat, supported by the continued operation of electronics production lines for the global market. A recovery in 2021-2022 is visible as a sharp peak in most of the lines. However, in 2023, the lines fell back to the "new normal" range: Indonesia and the Philippines remained around five percent, Vietnam slightly above, Malaysia and Thailand landed in the two-three percent range, and Singapore hovered around one percent as the global electronics cycle weakened. The dotted trend line in the graph shows a downward trend for almost all countries—an indication that the demographic dividend is beginning to wane in some middle-income economies, productivity is facing limits, and external risks (high interest rates, supply chain fragmentation, and climate change) are becoming more prevalent. The only notable exception is Vietnam; its trend line remains positively skewed thanks to the continued shift of manufacturing investment out of China.

Carbon Emissions in ASEAN Countries – 6

According to Figure 4, Singapore in the mid-1990s recorded carbon emissions of 12 tons of CO_2/capita due to its petrochemical industry and reliance on oil-fired electricity. However, in 2000, a shift to natural gas, energy efficiency policies, and the implementation of a carbon tax (2019) reduced carbon intensity, resulting in a downward-sloping linear trend, with emissions now hovering around 9 to 10 tons/capita. Malaysia's graph shows a steady

increase from 1994 to over 8 tons/capita in 2022. This surge is in line with the expansion of petrochemicals, electronics, and increased coal-fired power plants after 2003. Thailand's carbon emissions increased by 3.8 tons/capita. Automotive-chemical industrialization and urbanization drove emissions, while Demand-Side Management programs and the use of natural gas restrained growth; the result was a slight upward trend and relatively stable since 2015. Indonesia, despite having a large total national emissions, its massive population keeps per capita intensity low.

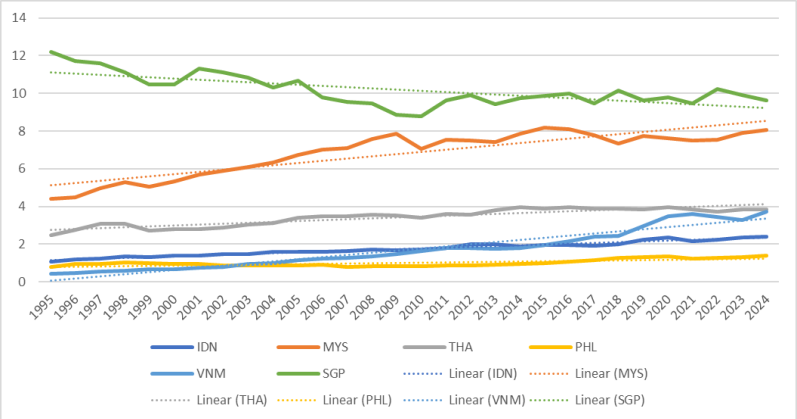

Figure 4.
Carbon Emissions in the ASEAN Region – 6
Source: WDI, processed data (2026)

The post-2010 increase, when coal accounted for over 60 percent of power generation, was significant; however, the contribution of hydro, geothermal, and biodiesel kept growth at the slowest level among the "big four." Vietnam, the "new initiator," has the steepest curve: from 0.3 tons to 3.6 tons/capita. The boom in export-oriented industries—particularly electronics and textiles—and the addition of large-capacity coal-fired power plants (PLTs) drove this surge. The government aims to peak coal-fired electricity emissions before 2030, but the current trend is still climbing. The Philippines remains at the bottom of the rankings—around 1.2 tons/capita. Its service-based economic structure, strong geothermal and hydroelectric mix, and low per capita electricity consumption explain this position. The slight increase since 2016 has been attributed to the addition of coal-fired power plants in Luzon–Visayas.

FDI in ASEAN Countries – 6

Based on Figure 5, which depicts FDI flows in six ASEAN countries since early 1995. A curve below zero indicates that foreign capital inflows exceed domestic capital outflows; conversely, a spike above zero indicates that domestic companies are aggressively investing abroad or that foreign investors are withdrawing funds. Each country's fluctuations are strongly influenced by global commodity cycles, financial crises, and national policies that signal "welcome" or create hesitation. Indonesia appears as the blue line, which is increasingly dipping downwards. After the shock of the 1997-1998 Asian Crisis temporarily curbed capital, a major wave of investment returned in 2005-2013 when coal and crude palm oil prices skyrocketed, regional autonomy opened up mining permits, and the MP3EI Masterplan promoted infrastructure. Once commodity prices collapsed in 2014-2016, flows

dwindled; However, the Job Creation Law, the ban on raw nickel exports, and the promise of an electric vehicle ecosystem caused the curve to plunge back into negative territory in 2022-2024, indicating a surge in foreign investment into the downstream nickel industry. Malaysia's trend was more flat, following the crisis, as large state-owned enterprises like Petronas and Khazanah purchased cheap assets overseas, resulting in a positive curve. The peak inflows actually occurred in 2008-2012, coinciding with the Economic Transformation Program (ETP) and the relocation of the electronics industry. The 1MDB scandal, falling oil prices, and repeated government changes weakened sentiment in 2015-2019; the pandemic pushed it back up again, before the RCEP and CPTPP sparked a mild recovery. Thailand's curve reversed several times: after the devastating floods of 2011, Japanese investment in reconstruction and the "eco-car" program drove large inflows (which fell well below zero). The 2016-2019 period actually recorded a positive surge of nearly USD 25 billion as Thai conglomerates—CP Group, PTT—purchased retail assets in China and the UK. Once the government announced “Thailand 4.0” and the Eastern Economic Corridor, foreign capital returned and the line fell again, but coups and political unrest slowed the pace.

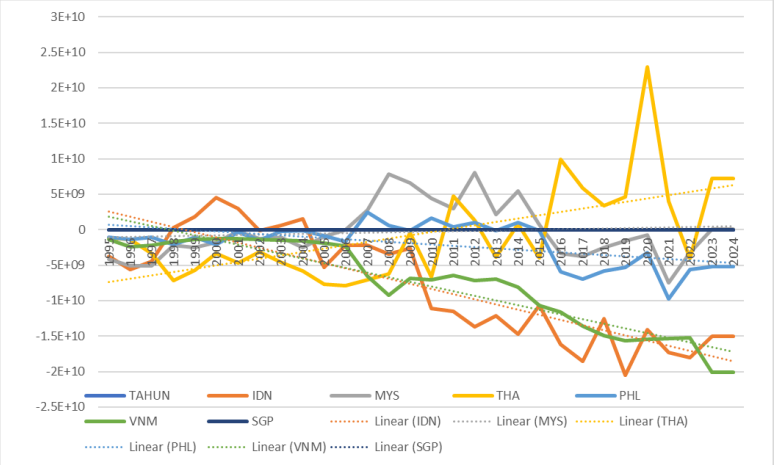

Figure 5.
FDI in the ASEAN Region – 6
Source: WDI, processed data (2026)

The Philippines has remained relatively flat around zero. The 2000s were marked by growth in BPOs, remittances, and a property boom—enough to make the line slightly negative (inflow). The TRAIN tax reform, the debate over foreign ownership limits, and geopolitical uncertainty during the Duterte era discouraged investors (the line moves upward). The CREATE Act of 2022, which cuts corporate taxes and allows for 100 percent ownership in renewable energy, is starting to attract FDI again, though the scale is not as dramatic as its neighbors. Vietnam represents the biggest story of manufacturing transformation. Since joining the WTO in 2007, its curve has steadily fallen into negative territory: Samsung, Intel, and hundreds of garment and electronics factories have made this country Asia's new "factory floor." The 2011-2012 credit crisis was only a brief respite; Then, the US-China trade war and the "China-plus-one" strategy drove a strong influx of investment from 2018 to 2024, reinforced by the EU-Vietnam Free Trade Agreement (FTA) and plans by Lego, Apple, and Foxconn to shift supply chains. Singapore remained nearly

flat at around zero but gradually trended upward—reflecting its role as a financial hub: inflows were substantial, but outflows, via Temasek, GIC, and regional tech startups, grew even faster. Even when borders were closed due to COVID-19, investment deals continued to be processed virtually through Singaporean entities, leaving the graph largely unchanged.

Descriptive Statistical Analysis

The descriptive statistics in this study are shown in Table 2. Based on the descriptive statistics, the average Renewable Energy (REC) was 23.93056, with a median of 23.65000. This value ranged from 74.50000 to 0.300000, indicating considerable variation in renewable energy development. The standard deviation is 18.544, indicating that the data are not too spread out from the mean. The REC distribution is also relatively normal, as indicated by a skewness of 0.36 and a kurtosis of 2.36, which is close to the normal distribution (kurtosis = 3).

Table 2.
Descriptive Statistics

	REC	GDP	CO2	FDI
Mean	23.93056	3.269848	1.053801	-14.33908
Median	23.65000	3.936204	1.070209	-22.60938
Maximum	74.50000	14.36197	2.499896	24.54755
Minimum	0.300000	-14.48915	-0.864030	-26.13709
Std. Dev.	18.54443	3.633444	0.895793	17.75809
Skewness	0.361064	-1.653251	-0.007254	1.574603
Kurtosis	2.369673	8.284509	1.786347	3.515464
Jarque-Bera	6.890868	291.4424	11.04873	76.37398
Probability	0.031891	0.000000	0.003988	0.000000
Sum	4307.500	588.5727	189.6841	-2581.034
Sum Sq. Dev.	61557.34	2363.143	143.6378	56447.63
Observations	180	180	180	180

Source: Eviews, (2026)

Economic growth (GDP) has an average of 3.269848 with a relatively high standard deviation of 3.633444, indicating significant variation between observations in gross domestic income. The GDP distribution shows a skewness of -1.65 and a kurtosis of 8.28, indicating that the data tends to be more pointed. Carbon emissions (CO2) have an average of 1.05 with a standard deviation of 0.90. The distribution is nearly symmetrical (skewness of -0.007) with a kurtosis of 1.79, indicating a flatter distribution than a normal distribution. Foreign direct investment (FDI) shows an average of -14.34 with a standard deviation of 17.76. The distribution is skewed to the right (skewness of 1.57) and a kurtosis of 3.52, slightly more pointed than a normal distribution.

Regression Estimation Results

There are three methods for estimating panel data: the Pooled Least Squares Method (PLS), the Fixed Effects Method (FEM), and the Random Effects Model (REM). The panel data regression results are as follows:

Table 3.
Model Selection Test Results

Test	Result	Conclusion
Chow Test	Prob 0.0000	FEM
	P-value < 5%	
Hausman Test	Prob 0.0002	FEM
	P-value < 5%	

Source: Author, processed data (2026)

Based on Table 3, the Chow test was used to select between CEM and FEM. The Chow test's probability value was 0.0000 < 0.05, indicating that the FEM model was selected. To select the best model between FEM and REM, the Hausman test was performed. The test results showed a probability value of 0.0002 < 0.05, indicating that the FEM model was selected.

Panel data regression aims to examine the influence between variables. In this study, the variables used are renewable energy, economic growth, carbon emissions, and FDI in ASEAN-6 countries. The panel data regression results are as follows:

Table 4.
Fixed Effect Model (FEM)

Hasil Regresi FEM				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	48.53056	1.068852	45.40436	0.0000***
GDP	0.231170	0.046993	4.919248	0.0000***
CO2	-5.887226	0.244790	-24.05013	0.0000***
FDI	0.064220	0.009677	6.636408	0.0000***
Statistik				
R-squared	0.966723	Mean dependent var		4.717212
Adjusted R-squared	0.965166	Sum squared resid		153.2240
F-statistic	620.9575	Durbin-Watson stat		0.863349
Prob(F-statistic)	0.000000			
Fixed Effects (Cross)				
IDN--C	0.335290			
MYS--C	-4.208887			
PHL--C	-9.167860			
SGP--C	12.51806			
THA--C	-6.019993			
VNM--C	6.543392			

Source: Author, processed data (2026)

Based on the results of an estimated analysis of the impact of economic growth, carbon emissions, and FDI on renewable energy in five developing countries using the Fixed Effects method, the complete model equation for this study is:

$$REC = 48.53 + 0.231\ GDP\ - 5.887\ LNCO2E + 0.064\ LNFDI + \varepsilon$$

The estimation results using the FEM model show that the GDP variable coefficient is 0.231 with a probability value of 0.000, indicating a positive and significant effect on renewable energy in the ASEAN-6 countries in this study. The carbon emissions variable has a coefficient value of -5.887 and a probability value of 0.000, indicating a negative and significant effect on renewable energy. The FDI variable has a coefficient value of 0.064 and a probability value of 0.000, indicating a positive and significant effect on renewable energy in the ASEAN-6 countries.

Partially (t-test) using a 95% confidence level or α = 5%, the results show a probability value for the GDP variable of 0.000 or <α = 0.05, meaning Ha is accepted, meaning that economic growth has a partial significant effect on renewable energy. A probability value of 0.000 or less than 0.05 for the carbon emissions variable indicates that Ha is accepted, meaning it has a significant partial effect on renewable energy. A probability value of 0.000 or greater for the FDI variable is <0.05, meaning Ha is also accepted, meaning the variable has a significant partial effect on renewable energy.

The simultaneous F-test obtained an F-statistic of 0.965166. Furthermore, the F-statistic of 0.000 or <0.05 indicates that GDP, carbon emissions, and FDI significantly influence renewable energy simultaneously in ASEAN-6 countries. Based on panel data estimation using the Fixed Effects Model (FEM), the coefficient of determination (R-square) was 0.966723, indicating that 96.66% of the variation in renewable energy in ASEAN-6 countries is determined by GDP, carbon emissions, and FDI, while the remainder is determined by other variables not included in the study.

Table 5.
Classical Assumption Test

Heteroscedasticity				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	4.398341	0.699717	6.285886	0.0000
GDP	-3.39E-12	2.87E-12	-1.183107	0.2387
CO2E	-0.356208	0.286803	-1.241993	0.2163
FDI	3.62E-11	3.28E-11	1.103861	0.2715
Multicollinearity				
	GDP	CO2	FDI	
GDP	1.000000	-0.062474	-0.204623	
CO2	-0.062474	1.000000	0.013502	
FDI	-0.204623	0.013502	1.000000	

Source: Author, processed data (2026)

Based on the results of the heteroscedasticity test, the probability value is greater than the 5% significance level, indicating that H0 is accepted or free from heteroscedasticity. The results of the multicollinearity test indicate that the correlation coefficients between the independent variables are generally below the critical threshold of 0.8. Overall, there is no indication of significant multicollinearity among the independent variables in the model.

The Effect of Economic Growth on Renewable Energy in ASEAN – 6

The regression results show that GDP has a positive and significant effect on renewable energy consumption in six ASEAN countries. Higher levels of economic growth drive renewable energy consumption and new renewable energy capacity, which in turn

significantly support economic development and employment (Maulana et al., 2024). The statistical significance indicates that this relationship is not a coincidence but has a strong empirical basis. These results align with energy transition theory and the Environmental Kuznets Curve (EKC) hypothesis, which states that in the early stages of economic development, countries tend to rely on fossil fuels. However, after reaching a certain income level, they begin to shift to more environmentally friendly energy sources.

This finding is also consistent with research by Guliyev (2025) that found a significant relationship between renewable energy consumption and economic growth; thus, renewable energy is proven to be a crucial element in sustainable and decarbonized economic growth strategies (Alam & Manigandan, 2025). This finding is further supported by research by Al Numan et al., 2025; Bergougui & Zambrano-Monserrate, 2025; Xie et al., 2025, which found a positive and significant impact of economic growth on the renewable energy transition. Therefore, economic growth is crucial for driving the renewable energy transition, particularly digitalization and green policies (Alam & Manigandan, 2025). Renewable energy is a strategic factor in maintaining sustainable economic growth and increasing the efficiency of the industrial and environmental sectors (Lalremruati & Khanna, 2025).

Countries such as Vietnam, the Philippines, and Indonesia, which are experiencing rapid economic growth, are beginning to demonstrate a strong commitment to the energy transition by adopting feed-in tariff policies, eliminating fossil fuel subsidies, and creating domestic carbon markets. For example, Indonesia is targeting a 23% renewable energy mix by 2025 through large-scale solar power projects and biomass utilization. The ADB (2022) notes that stronger economic performance in Indonesia and Vietnam has enabled higher investment in clean energy, particularly solar and wind. The same is true in Malaysia and Thailand, where economic growth supports the strengthening of clean energy policy frameworks, including the establishment of renewable electricity purchase quotas. Singapore, despite being a small country, integrates its economic growth with clean energy innovation and high efficiency through investment in green technology. Sadorsky (2009) found that in developing countries, GDP growth significantly increases renewable energy consumption due to increasing demand and investment capacity. In other words, economic growth encourages countries to meet increasing energy demand with cleaner sources, especially amid global pressures on climate change and commitments to the Sustainable Development Goals (SDGs).

The Effect of Carbon Emissions on Renewable Energy in ASEAN – 6

Regression results show that carbon emissions have a negative and significant impact on renewable energy consumption in five developing countries. This means that the higher the carbon emissions, the lower the renewable energy consumption. This finding strengthens the argument that the transition to clean energy is not only crucial for national energy security and independence but also highly effective in reducing environmental pressures and achieving national climate targets. High carbon emissions can reduce the efficiency of renewable energy contributions, leading to stagnation in the energy transition (Ehigiamusoe & Dogan, 2022). This finding aligns with research by Ungureanu & Rusănescu (2025), who stated that high carbon emissions and dependence on fossil fuels reduce the efficiency of the transition to bioenergy. High carbon emissions pose serious obstacles to the renewable energy transition, both technically, economically, and socially. This research is also supported by research by Alam & Manigandan, 2025; Ali et al., 2022; Chen et al., 2023;

Yuan et al., 2022; Zhu et al. (2025) concluded that carbon emissions negatively impact renewable energy development, both through regulatory barriers, a lack of incentives, and public and market resistance.

The Asian Development Bank (2023) stated that ASEAN countries that have significantly increased their renewable energy capacity since 2015, particularly Vietnam and the Philippines, experienced a decline in CO_2 emission growth rates, despite their continued increase in energy demand. This demonstrates that economic growth and increasing energy demand do not necessarily conflict with the environmental agenda, as long as the national energy mix is directed toward low-carbon sources. A recent study by Wang, Zhang, and Nguyen (2023) found a statistically significant inverse relationship between the share of renewable energy and CO_2 emissions, indicating that renewable energy expansion plays a central role in national decarbonization strategies. Furthermore, Sari et al. (2025) stated that the transition from fossil-based energy and investment in renewable energy sources have a clear impact on reducing emissions, demonstrating that clean energy investments are not merely symbolic but have a real impact on the national emissions structure. In the industrial sector, Li et al. (2024) also found that renewable energy's ability to reduce carbon emissions in the industrial sector is significant across the ASEAN region, particularly in the manufacturing and electricity sectors.

However, countries like Malaysia and Thailand still show relatively slow rates of emission reduction due to their high dependence on fossil fuels, particularly coal and natural gas. Although initial investments in renewable energy have been made, incomplete implementation and the presence of fossil fuel subsidies hinder efficient decarbonization. This suggests that the negative relationship between renewable energy and carbon emissions also depends on the extent to which a country is committed to a systemic and consistent energy transition. Lee et al. (2025) concluded, in their projections of low-carbon growth scenarios in Southeast Asia, that increased adoption of renewable energy shows a measurable reduction in CO_2 emissions in high-growth scenarios. This confirms that even in expansionary economic conditions, clean energy can still reduce emissions if prioritized in public policy. This negative and significant relationship provides strong empirical evidence that the transition to renewable energy is a key strategy for reducing carbon emissions in the ASEAN region, without sacrificing economic growth. This makes renewable energy not only a technical solution, but also an indicator of the effectiveness of national energy policies that have a direct impact on environmental performance and long-term sustainability.

The Effect of FDI on Renewable Energy in ASEAN – 6

Regression results show that FDI has a positive and significant effect on renewable energy consumption in six ASEAN countries. This means that the higher the flow of foreign direct investment, the greater the consumption of renewable energy in those countries. Research conducted by Manni et al. (2025) found that in both the short and long term, increased FDI is directly associated with increased renewable energy consumption. In this context, FDI provides more than just capital; it brings clean technology, managerial expertise, and operational efficiencies needed to accelerate the energy transition. This is further supported by research (Numan et al., 2025; Charfeddine et al., 2025; Ebaidalla, 2025; Soto et al., 2025). FDI encourages renewable energy adoption by opening access to new technologies, accelerating infrastructure development, and facilitating global market integration.

The positive relationship indicates that FDI plays a role in technology transfer, capital increases, and strengthening renewable energy infrastructure, ultimately accelerating the clean energy transition. Hanif et al. (2022) in their study proved that FDI not only encourages renewable energy development but also indirectly reduces carbon emissions through improved energy efficiency. This finding is reinforced by Abdul Bahri & Wye (2024), who showed that the relationship between FDI and the clean energy mix in ASEAN remains significant despite variations between countries. Furthermore, the quantile approach in the study by Maulidar et al. (2022) states that the impact of FDI on renewable energy is more pronounced in countries with high energy consumption levels. This means that countries with large energy needs and more mature infrastructure tend to benefit more from foreign investment. From a policy perspective, Tan et al. (2024) concluded that FDI acts as a catalyst for green growth in ASEAN. They emphasized the importance of synergy between energy, environmental, and investment climate policies to ensure that FDI inflows are not merely speculative but truly support sustainable development. These results collectively lead to one important conclusion: FDI is not only a source of funds but also an agent of energy transformation in Southeast Asia. Through increasing renewable energy production capacity, technology transfer, and creating green jobs, FDI has proven to be a strategic instrument for achieving regional clean energy targets.

CONCLUSION

Economic growth has been shown to positively contribute to the expansion of renewable energy, suggesting that increased economic capacity in the region can encourage investment and policies that support the use of more environmentally friendly energy. This reinforces the understanding that economic progress is not always an obstacle to the energy sustainability agenda, especially if countries are able to allocate resources to innovation and the development of green energy infrastructure. Conversely, carbon emissions negatively impact renewable energy development. This suggests that emissions are not merely a byproduct of economic activity but can also hinder the transition to clean energy. These findings underscore that achieving sustainability requires more than economic growth alone, requiring structural changes in the energy system and comprehensive emissions reduction policies. This provides a new contribution to the literature, which has traditionally viewed emissions primarily as an economic consequence without examining their inhibiting effects on clean energy development.

Foreign direct investment (FDI) also positively impacts renewable energy. However, the policy implications of this finding cannot be oversimplified. While FDI has the potential to be a major catalyst for clean energy adoption, its success depends heavily on the ability of ASEAN countries to direct this investment to strategic sectors that support the energy transition and avoid investments that reinforce dependence on fossil fuels. Therefore, it is crucial to build a selective policy framework that can direct FDI to projects with a strong environmental orientation.

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