



The Role of Green Energy on Reducing the Carbon Emission in ASEAN Countries

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ABSTRACT

Recently, carbon (CO₂) emissions have become a global problem that needs attention from researchers and regulators. Therefore, the current study examines the impact of green energy on CO₂ emissions in ASEAN countries. The current study has used energy import as the control variable. The present research has used secondary data collected from "world development indicators" (WDI) from 2001 to 2018. The current article has used the fixed-effect model (FEM) to test the linkage among constructs. The results revealed that green energy and energy import are negatively associated with CO₂ emission. The study provides help to the policymakers while formulating policies related to controlling CO₂ emissions.



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1. Introduction

Climate change is a massive threat to humanity. Several climate change agreements and conferences have been conducted worldwide (Bakhtyar, 2017; Chien, Kamran, et al., 2021). The well-known "greenhouse effect" has drawn the attention of scientists, policymakers, and the general public to the relationship between CO₂ and climate change. Since the early 1990s, however, this impact has stabilized in most developed economies till 2005. Global fossil fuel emissions have grown considerably since 2000, owing to increasing development in some nations. Nonetheless, emissions in the United States and Europe have been declining for more than a decade, slowing the rising rate globally (Baloch et al., 2021; Chien, Kamran, et al., 2021; Shittu, Hassan, & Nawaz, 2018).

From 1906 to 2005, the global temperature increased by around 0.700 degrees Celsius. This temperature is predicted to rise in the future due to global warming concerns. Four major pathways contribute to global warming, with CO₂ being the most significant. Even though ASEAN nations' present CO₂ emissions are lower than those of China and the United States, the ASEAN area is expected to be severely impacted by sea-level rise in the next fifty years. Because of the rising tendency, the growth in CO₂ emissions in ASEAN may be large from time to time. Furthermore, if no action is taken, it is expected to be comparable to China and the United States. Brunei produced the most CO₂ emissions (23.69 tonnes per capita), followed by Malaysia (7.10 tonnes per capita) and Singapore (7.10 tonnes per capita) (6.39 tonnes per capita).

On the other hand, Myanmar, Laos, and Cambodia produced the least, with 0.23, 0.30, and 0.33 tonnes per capita, respectively. Human actions such as the use of fossil fuels and the combustion of biomass have an impact on the earth's atmospheric system. Energy

demand has skyrocketed because of the increasing rate of urbanization and industrialization over the last ten years. According to reports, the primary sources of CO₂ emissions in ASEAN countries are power generation and heat production, industry and construction, and transportation (Chien, Pantamee, et al., 2021; Fazal, Gillani, Amjad, & Haider, 2020; Lee, Hashim, Ho, Van Fan, & Klemeš, 2017).

The study will contribute to the literature like 1) highlight the global warming adverse effect on humanity, 2) the need for renewable energy (RE) to mitigate the CO₂ emission, 3) help the environmental policymakers to revamp their policies by focusing on RE, 4) Dogan and Seker (2016) and Liu, Zhang, and Bae (2017), tested the RE and CO₂ emission in MENA, Africa and G7 countries respectively whereas the present study has selected the ASEAN, 5) Cai, Sam, and Chang (2018), tested the clean energy with CO₂ emission whereas the present study used the green energy.

2. Literature Review

Global warming has been a source of concern not only in severely polluted nations but also across the world (Sun et al., 2020; Zhuang et al., 2021), and the primary driver of climate change is CO₂ emissions (Mohsin, Kamran, Nawaz, Hussain, & Dahri, 2021; Nawaz, Ahmad, Hussain, & Bhatti, 2020; Nawaz et al., 2021). In this context, Hu, Xie, Fang, and Zhang (2018), shared a view on the nexus of RE, democracy, and CO₂ emission. The study was conducted in 25 developing nations. The study concluded that RE and democracy result in reducing CO₂ emission, but in the case of democracy, the reduction is conditional with controlled democracy. In addition to this, no evidence of Environmental Kuznets Curves was found. The study also recommends prioritizing democracy and investment in renewable, i.e., green energy, particularly in Africa.

Similarly, this relationship with the addition of economic growth was also explored by Rahman et al. (2017) in both the long and short run. The study was conducted in 15 nations that are rated high in the consumption of RE. The study concluded that RE consumption reduces the CO₂ emission but, 1) in the case of the long run there is no causal nexus between both of these variables, 2) there is a bidirectional relationship between RE and CO₂ emission in the short run.

Apergis, Jebli, and Youssef (2018) also explored the nexus between RE, economic growth, and CO₂ emission in environmental Kuznets perspective in sub-Saharan Africa countries. The data selected from 1990 to 2014 was tested to check the relationship and the results proposed that a 10% increase in RE rate results in a 1.6% reduction in CO₂ emission. In the same way, Irandoust (2016) selected Nordic countries to test the nexus between green energy (RE) growth, environment taxes, and CO₂ emission with the application of the advanced technique i.e., advanced panel data. Info covering the tenure from 1991 to 2017 was collected from G7 and analyzed using the ARDL approach. The results of the study proposed that 1) the green growth reduces the CO₂ emission, 2) environmental taxes along with human capital also results in the reduction of CO₂ emission, 3) in both the long and short-run the GDP deplete CO₂ emission. Similarly, Zhang, Wang, and Wang (2017) tested the RE consumption heterogeneity with CO₂ emission and financial development from a Pakistani perspective. The results proved the heterogeneity of all the variables.

Energy has been identified as a critical aspect in attaining sustainable development. The function of RE consumption has been studied since it significantly impacts CO₂ emissions, and CO₂ emissions affect RE consumption (Jianjun et al., 2021; Nawaz et al., 2021; Shair, Shaorong, Kamran, Hussain, & Nawaz, 2021). Forgoing in view, Dogan and Ozturk (2017) explored the relationship between RE and CO₂ emission by analyzing the data collected from the USA. The results proposed a relationship between CO₂ emission, financial development, and RE from the global perspective. In the case of CO₂ emission, the RE consumption deletes, whereas, in the case of economic development, there is a positive association reported.

Similarly, this nexus was also tested by Charfeddine and Kahia (2019) in 24 nations of the MENA region. The data was selected from 1980 to 2015 and analyzed using PVAR

analysis. The results proposed that all the selected variables are significant i.e. CO2 emission, financial development, and RE in the selected MENA nations. Further, RE results in the reduction of CO2 emissions. The economic growth and RE are a bit weak in contributing to the environment, particularly in the MENA region. The study also strongly recommended the RE investment in MENA in the context of CO2 emission. Continuing the theme, Cai et al. (2018) investigated the CO2 emission with clean energy in G7 countries. The data was selected from 1965 to 2015. Canada, the United States of America (USA), Japan, the UK, France, Italy, and Germany were selected nations. The results proved that clean energy impacts CO2 emission.

3. Research Methods

This study examines the green energy impact on CO2 emission in ASEAN countries. The current study has used energy import as the control variable. The present research has used secondary data collected from WDI from 2001 to 2018. The current study equation is mentioned as under:

$$CO2_{it} = \alpha_0 + \beta_1 REP_{it} + \beta_2 REC_{it} + \beta_3 EI_{it} + e_{it} \tag{1}$$

Where;

CO2 = Carbon Emission

i = Country

t = Time Period

REP = Renewable Energy Production

REC = Renewable Energy Consumption

EI = Energy Import

The current study is taken CO2 emission as the predictive construct measured as the "carbon dioxide damage (% of GNI)." The present study used green energy as the independent variable and measured as the REP and REC. Finally, the current study has used energy import as the control variable. In addition, the recent study has used the Hausman test to select a suitable model. The Hausman test equation is given as under:

$$H = (b_1 - b_0) (Var(b_0) - Var(b_1)) (b_1 - b_0) \tag{2}$$

In equation (2), b_0 exposed the "null hypotheses" about the "random model" is suitable. In contrast, b_1 exposed the "alternative hypotheses" about "FEM" is suitable. In addition, FEM has been run because in FEM, "model parameters" are fixed. Moreover, it controls all "time-invariant" omitted constructs. The equation is mentioned as under:

$$Y_{it} = \beta_{1i} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + u_{it} \tag{3}$$

In equation (3), subscript (i) exposed the "individual country" that makes different countries regarding their characteristics and with understudy variables, the FEM equation given as under:

$$CO2_{it} = \beta_{1i} + \beta_2 REP_{it} + \beta_3 REC_{it} + \beta_4 EI_{it} + u_{it} \tag{4}$$

3.1 Research Findings

The current article has run the correlation to examine the multicollinearity among the predictors. Table 1 indicated that values are lower than 0.90 and show no multicollinearity. In addition, the results also exposed that REP, REC, and EI have a negative association with CO2 emission.

Table 1
Matrix of correlations

Variables	CO2	REP	REC	EI
CO2	1.000			
REP	-0.382	1.000		
REC	-0.299	0.433	1.000	
EI	-0.212	-0.322	-0.311	1.000

The study findings also show the Hausman test to select the suitable model. Table 2 indicates that the probability value is lower than 0.05, meaning that the FEM model is appropriate.

Table 2
Hausman test

	Coef.
Chi-square test value	3.669
P-value	0.038

The results in Table 3 related to the FEM revealed that green energy such as REP and REC and control variables such as energy import positively associated with CO2 emission in ASEAN countries. R square value (0.543) indicated that 54.3 percent changes in CO2 emissions are due to all predictors used in the study.

Table 3
Fixed effect model

CO2	Beta	S.D.	t-value	p-value	L.L.	U.L.	Sig
REP	-2.772	1.119	-2.47	0.032	-2.873	-0.992	**
REC	-1.973	0.654	-3.02	0.009	-3.933	-1.982	**
EI	-0.188	0.032	-5.88	0.000	-3.103	-0.982	***
Constant	6.983	2.762	2.53	0.028	1.146	2.933	**
R-squared		0.543	Number of obs				180
F-test		3.922	Prob > F				0.011

4. Discussion and Implications

The study results showed an association between all the variables, i.e., CO2 emission, REC, REP, and energy import. Further, there is a negative association between RE and CO2 emission. This outcome is matched with Jebli and Youssef (2017), who proposed a negative impact of REC on CO2 emission. The results are also in line with the study of Sinha and Shahbaz (2018), according to which green energy growth reduces CO2 emissions. Further, environmental taxes and human capital also reduce CO2 emissions. The study also tested REP with CO2 emission and proposed a negative association. The outcome is similar to Adewuyi and Awodumi (2017), according to which the production of RE includes plantation and forestry, which consume the CO2 found in the environment. Thus, the output of RE minimizes CO2 emissions. The results also get support from Chen, Wang, and Zhong (2019) study, who proposed that increase in the production of RE cause to reduction the CO2 emission. Finally, the study also tested the nexus between energy import and CO2 emission and proposed a negative association. These results are also supported by the study of Inglesi-Lotz and Dogan (2018), which proposed that an increase in energy import results in a decrease in CO2 emission. The study also suggested that energy export also results in a negative association. Similarly, Dong, Sun, and Hochman (2017) also support the present study results, who proposed that the increase in energy import results in decreased CO2 emission.

The present study has a unique place in green energy and CO2 emission in terms of contribution. The present study will help the environment-related policymakers closely look at the existing and formulation of firms' policies and their implementation in the future. The country's industrial sector always remains worried about the environment, whereas this study will help the environmental professionals reconsider their ecological planning.

5. Limitations and Future Directions

Like several studies, the present research also pertains to the number of limitations, which can be overcome in the upcoming literature regarding green energy and CO2 emission. The present study examined the CO2 emission in the context of green energy by ignoring some other factors, i.e., economic development, environmental taxes, etc., which may act as a critical player towards the CO2 emission in the country and globally. The authors may test the relationship in other areas or regions. The present study is also

pertaining the time as well as financial constraints. Understanding the sources of emissions patterns in nations where emissions are regularly declining might suggest if efforts to decarbonize energy systems and combat climate change are underway or if they are just reflecting long-term trends in national and global economies. Furthermore, despite enormous attention paid to climate change policies and actions, it is unclear if they have consistently altered national emission trends across all nations.

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