Representation of Energy Consumption on CO2 Emissions in Cambodia with ARDL Approach

Rachmad Santoso[1],Suryaning Bawono[2], Andik Priyanto[3], Muhammad Birrul Alim[4]
[1,2,3]STIE Jaya Negara Tamansiswa Malang, Indonesia
[4]University of Jember, Indonesia

Abstract

This study tries to determine the long-term and short-term relationship between several variables related to CO2 emissions, such as the use of fossil fuels, renewable energy, and Cambodia's economic development. We use the World Bank as a supplementary source for statistics data, namely data from 2000 to 2020. We found that when economic growth increases, it will give a negative sentiment toward CO2 emissions in Cambodia. This is also in line with other variables, such as consumption of fossil energy, where when there is an increase, it will also make a negative contribution to the increase in CO2 emissions. However, other variables, such as the consumption of renewable energy, have a positive contribution to reducing CO2 emissions in Cambodia. The choice of using renewable or fossil energy is very influential in increasing CO2 emissions, the current condition where renewable energy is still minimally used in Cambodia is one of the reasons why the increase in CO2 emissions there tends to continue to increase.

Keywords: Economic Growth, Renewable Energy Consumption, CO2 Emissions, Cambodia
JEL Classification: C31, I25, O40.

July 6,2022 Accepted: August 1,2022
DOI : 10.54204/TAJI/Vol712022009

Background

Energy is required to carry out economic operations in various economic sectors, both for production and consumption purposes (Bashir, Thamrin, Farhan, Mukhlis, & Atiyatna, 2019). For the community's success, energy must be used as much as feasible as a natural resource, and its management must follow the principles of sustainable development (Ali, Anufriev, & Amfo, 2021). From the aspect of supply, energy resources can be either unrenewable resources or renewable resources (Jahanger, Chishti, Onwe, & Awan, 2022).

Renewable energy or green energy is an energy source whose formation does not come from organic bodies (Assad, Nazari, & Rosen, 2021). Some opinions suggest that green energy is clean energy that does not pollute or add to atmospheric pollutants (Pata & Caglar, 2021). In the future, all green energy should be the main policy of energy development and utilization. So, this renewable energy must be put forward, not used as an alternative. Because basically, this energy source is a natural energy source that can be directly used freely and can be renewed continuously (Chau, et al., 2022).

Fossil energy is oil, natural gas, and coal, which are limited in availability in nature and, therefore non-renewable. By using fossil energy, it causes various impacts such as greenhouse gas emissions, carbon dioxide that destroys nature, and other impacts so other alternatives are needed, namely renewable energy, which is a natural energy source that can be directly used

freely and renewed continuously and not limitedly. (Dingbang, Cang, Qing, Lili, & Caiyun, 2021).

Energy consumption is an integral and inseparable part of a country's economic development (Li & Leung, 2021). Population growth, improved lifestyles, improved production, and economic competitiveness are some of the reasons for the high demand for energy. Excessive burning of fossil fuels results in increased carbon dioxide, leading to adverse environmental effects such as global warming (Jeon, 2022).

The continuous use of fossil energy will result in the energy reserves being depleted. The usage of energy, however, keeps rising. A nation's ability to develop economically may be at risk from this. Therefore, to achieve energy security in the future, Cambodia needs to develop and switch to renewable energy consumption so that the sustainability and availability of energy can be met continuously (Phoumin & Kimura, 2019).

The determinants of a country's progress not only depend on its natural resources and geographical position but also the existence of its energy sources as a formidable force to accelerate a country's economic activities (Kim & Park, 2022). Due to the finite supply of fossil fuels, the pace of population expansion, and economic growth, energy consumption will continue to rise. For this reason, it is necessary to develop renewable energy and conserve green energy or non-fossil energy, which if managed properly, these energy sources will not run out (Khezri, Heshmati, & Khodaei, 2022).

According to Alim (2022), it is explained that economic growth is a process in people's lives, namely changes in politics, values, social structures, and economic structures. Where every country tries to increase economic growth every year, so that economic activity increases, one of which is in the industrial sector where a lot of energy is used, especially fossil energy (Okoye, et al., 2022). The energy supply in Cambodia uses a lot of fossil energy which will encourage higher CO2 emissions (Phoumin & Kimura, 2019). This study tries to determine the long-term and short-term relationship between several variables related to CO2 emissions, such as the use of fossil fuels, renewable energy, and Cambodia's economic development.

Research Methods

We use the World Bank as an additional source for statistical data, namely data from 2000 to 2020. Two alternative time series models will be used to investigate the ensuing variables. In this study, economic growth is measured using national GDP. The factors in this study include economic growth, fossil fuel usage, and consumption of renewable energy because they show the long- and short-term relationships between the three variables, with CO2 emissions as the dependent variable. Here's the econometric model we use:

$$COE_t = \beta_0 + \beta_1 COE_{t1} + \beta_2 COE_{t2} + \beta_3 EG_{t3} + \beta_4 EG_{t4} + \beta_5 REC_{t5} + \beta_6 REC_{t6} + \beta_7 REC_{t7} + \beta_8 FEC_{t8} + e_t$$

Where the Gross domestic product is GDP, CO2 emissions is COE internet literacy is IL, and education is E, the error term is e, and time series is t.

Dynamic ARDL was used in the study. Zhang et al. (2021) claim that ARDL is a regression method that includes the lag of both the dependent and independent variables simultaneously. Using this model can analyze long-term relationships when the explanatory variables are a mixture of 1(1) and 1(0).

Result and Discussion

Based on the factors of the study, descriptive data are shown in Table 1.

Table 1. Descriptive Data

	COE	REC	FEC	EG
Mean	85.84640	30.04190	75.53263	7.226089
Median	90.52483	29.97000	75.71844	7.142571
Maximum	105.1484	32.53000	77.30713	13.25009
Minimum	57.81394	27.24000	72.38192	-3.096007
Std. Dev.	16.59565	1.461997	1.149612	3.448108
Skewness	-0.512761	0.058797	-0.800968	-1.402324
Kurtosis	1.702015	2.241282	3.831317	5.817277
Jarque-Bera	2.394402	0.515795	2.850127	13.82771
Probability	0.302038	0.772674	0.240493	0.000994
Sum	1802.774	630.8800	1586.185	151.7479
Sum Sq. Dev.	5508.310	42.74872	26.43215	237.7890
Observations	21	21	21	21

Mean, min, max, and standard deviation are used to express the findings of descriptive statistics. COE Minimum 57.81, COE Maximum 105.14, and COE Standard Deviation 16.65. REC Minimum 27.24, REC Maximum 32.53, REC Standard Deviation 1.46, etc. The ARDL model should not be used to forecast the value without first performing a stationary test. By looking at the error component, which also incorporates any possibility for autocorrelation, the ADF algorithm may determine if a series is stationary or not. The results are as follows:

Table 2. Unit Root Test

	Unit Root	ADF Test stat.	Signif.	Be told
Economic growth (EG)	Level	-1.431593	0.5451	
	First Diff	-3.051408	0.0490	Stationer
CO2 emissions (COE)	Level	0.033579	0.9508	
	First Diff	-3.034884	0.0505	
	Second Diff	-4.415588	0.0035	Stationer
Fossil energy consumption (FEC)	Level	-1.299994	0.6026	
	First Diff	0.365948	0.9742	
	Second Diff	-7.779596	0.0000	Stationer
Renewable energy consumption (REC)	Level	-2.481915	0.1343	
	First Diff	-2.308809	0.1817	
	Second Diff	-3.740549	0.0161	Stationer

From the table above, it can be concluded that EG data are stationary in the first difference data, while FEC, COE, and REC data are stationary in the second difference. We may continue with the ARDL estimate because all the data are stationer.

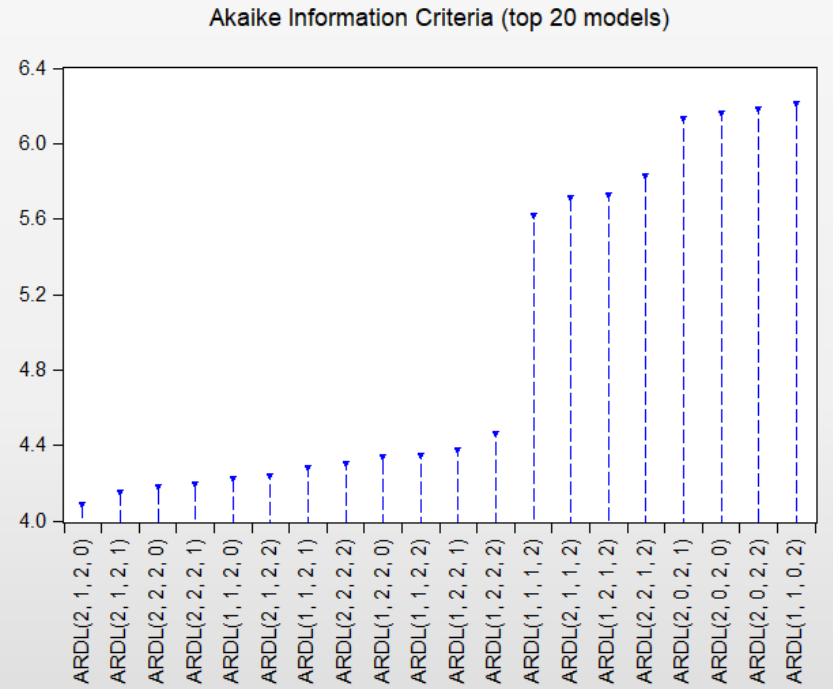

Figure 1. AIC Optimum Lag Test

In order to determine which lag should be utilized in the subsequent test, optimal lag testing is conducted; as can be seen in the figure above, 2,1,2,0 lag is the most recommended.

Tabel 3. Bounds Test

Stat. Test	Value	Signif.	I(0)	I(1)
F-stat.	65.91026	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

Asympotic : n=1000

According to Table 4's findings of the Limit test. This shows that the four variables under study—CO2 emissions, economic growth, use of renewable energy, and use of fossil fuels—are cointegrated throughout time or move in the same direction because the F statistic value is greater than I(0) and I(1).

Tabel 4. ARDL Results

	Coeff.	Std. Error	t-Stat.	Prob.*
D(COE(-1),2)	-0.074293	0.079520	-0.934259	0.3775
D(COE(-2),2)	-0.126540	0.083342	-1.518332	0.1674

D(EG)	0.557856	0.128443	4.343203	0.0025
D(EG(-1))	-1.325560	0.165747	-7.997497	0.0000
D(REC,2)	-1.560237	0.261435	-5.967964	0.0003
D(REC(-1),2)	-1.891533	0.272827	-6.933083	0.0001
D(REC(-2),2)	-2.460354	0.264306	-9.308740	0.0000
D(FEC,2)	2.492300	0.416514	5.983710	0.0003
C	-0.314644	0.406525	-0.773985	0.4612
R-squared	0.957898			

The ARDL model's R-squared value is 0.95, which means that each of its independent variables—economic growth, consumption of renewable energy, and consumption of fossil energy—can account for 95% of the variance in the dependent variable, CO2 emissions. This demonstrates how well the research paradigm works for research. Judging from the ARDL estimation results, the variables EG and EG(-1) each have a probability value of 0.0025 and 0.0000, which indicates that the economic growth factor this year and the previous year is a factor that affects co2 emissions. For example, when the economic growth rate this year increases by 1%, it will result in an increase in co2 emissions of 0.25 percent. Similarly, the variable REC(-1) has a probability value of 0.0001, which indicates that when the level of renewable energy consumption last year increased by 1 percent, it would cause a decrease in co2 emissions of 0.01 percent. This shows that when economic growth increases, it will give a negative sentiment toward co2 emissions in Cambodia. This is also in line with other variables such as fossil energy consumption, where when there is an increase, it will also make a negative contribution to the increase in co2 emissions. However, other variables, such as the consumption of renewable energy, have a positive contribution to reducing CO2 emissions in Cambodia.

Table 5. Model Test Results In The Long And Short Term

	Coeff.	Std. Error	t-Stat.	Prob.
C	-0.314644	0.406525	-0.773985	0.4612
D(COE(-1), 2)*	-1.200833	0.131955	-9.100295	0.0000
D(EG(-1))	-0.767704	0.220005	-3.489483	0.0082
D(REC(-1), 2)	-5.912124	0.651059	-9.080775	0.0000
D(FEC,2)**	2.492300	0.416514	5.983710	0.0003
D(COE(-1), 3)	0.126540	0.083342	1.518332	0.1674
D(EG, 2)	0.557856	0.128443	4.343203	0.0025
D(REC, 3)	-1.560237	0.261435	-5.967964	0.0003
D(REC(-1), 3)	2.460354	0.264306	9.308740	0.0000

According to the table above, there is a significant negative relationship between the COE and COE(-1) variables, as well as a significant negative relationship between the EG(-1) variable and the COE(-1) variables, indicating that in the short term, Cambodia's CO2 emissions and economic growth from the previous year both contributed to the increase in CO2 emissions this year. In contrast to the significant positive relationship between the COE and FEC variables, this shows that the results of this analysis strengthen the ARDL estimation in Table 4, which also explains that in the short and long term, the variable fossil energy consumption has a strong and positive effect on increasing CO2 emissions in the Cambodia. However, the variable of

renewable energy consumption has a significant negative effect on co2 emissions in Cambodia in the short term. This indicates that in Cambodia, the choice of using renewable or fossil energy is very influential in increasing CO2 emissions, the current condition where renewable energy is still minimally used in Cambodia is one of the reasons why the increase in CO2 emissions there tends to rise steadily.

Conclusion

We find that the estimated variables have a varied relationship with co2 emissions, such as renewable energy consumption tends to have a significant and inverse relationship with co2 emissions, but the other two variables, such as fossil energy consumption and economic growth, have a direct and significant relationship with increasing co2 emissions in Cambodia. The ARDL test found that when economic growth increases, it will give a negative sentiment toward CO2 emissions in Cambodia. This is also in line with other variables, such as consumption of fossil energy, where when there is an increase, it will also make a negative contribution to the increase in CO2 emissions. However, other variables, such as the consumption of renewable energy, have a positive contribution to reducing CO2 emissions in Cambodia. The choice of using renewable or fossil energy is very influential in increasing CO2 emissions, the current condition where renewable energy is still minimally used in Cambodia is one of the reasons why the increase in CO2 emissions there tends to continue to increase.

References

Ali, E., Anufriev, V., & Amfo, B. (2021). Green economy implementation in Ghana as a road map for a sustainable development drive: A review. *Scientific African, 12 (1)*, 89-98.

Alim, M. (2022). Impact of Taxes and Technological Improvement for Economic Growth,. *Tamansiswa Accounting Journal International, 4 (1)*, 72-77.

Assad, M., Nazari, M., & Rosen, M. (2021). Design and Performance Optimization of Renewable Energy Systems. *Academic Press 1 (1)*, 1-15. https://doi.org/10.1016/B978-0-12-821602-6.00001-8.

Bashir, A., Thamrin, K., Farhan, M., Mukhlis, & Atiyatna, D. (2019). The Causality between Human Capital, Energy Consumption, CO2 Emissions, and Economic Growth: Empirical Evidence from Indonesia. *International Journal of Energy Economics and Policy, 9 (2)*, 98-104.

Chau, K., Moslehpour, M., Tu, Y.-T., Tai, N., Tien, N., & Huy, P. (2022). Exploring the impact of green energy and consumption on the sustainability of natural resources: Empirical evidence from G7 countries. *Renewable Energy, 196 (1)*, 1241-1249. https://doi.org/10.1016/j.renene.2022.07.085.

Dingbang, C., Cang, C., Qing, C., Lili, S., & Caiyun, C. (2021). Does new energy consumption conducive to controlling fossil energy consumption and carbon emissions?-Evidence from China. *Resources Policy, 74 (1)*, https://doi.org/10.1016/j.resourpol.2021.102427.

Jahanger, A., Chishti, M., Onwe, J., & Awan, A. (2022). How far renewable energy and globalization are useful to mitigate the environment in Mexico? Application of QARDL and spectral causality analysis. *Renewable Energy, 1 (1)*, https://doi.org/10.1016/j.renene.2022.10.081.

Jeon, H. (2022). CO2 emissions, renewable energy and economic growth in the US. *The Electricity Journal, 1 (1)*, https://doi.org/10.1016/j.tej.2022.107170.

Khezri, M., Heshmati, A., & Khodaei, M. (2022). Environmental implications of economic complexity and its role in determining how renewable energies affect CO2 emissions. *Applied Energy, 306 (2)*, https://doi.org/10.1016/j.apenergy.2021.117948.

Kim , D., & Park, Y.-J. (2022). Nonlinear causality between energy consumption and economic growth by timescale. *Energy Strategy Reviews, 44 (1)*, https://doi.org/10.1016/j.esr.2022.100949.

Li, R., & Leung, G. (2021). The relationship between energy prices, economic growth and renewable energy consumption: Evidence from Europe. *Energy Reports, 7 (1)*, 1712-1719.

Okoye, L., Adeleye, B., Okoro, E., Okoh, J., Ezu, G., & Anyanwu, F. (2022). Effect of gas flaring, oil rent and fossil fuel on economic performance: The case of Nigeria. *Resources Policy, 77 (1)*, https://doi.org/10.1016/j.resourpol.2022.102677.

Pata, U., & Caglar, A. (2021). Investigating the EKC hypothesis with renewable energy consumption, human capital, globalization and trade openness for China: Evidence from augmented ARDL approach with a structural break. *Energy, 216*, 79-91.

Phoumin, H., & Kimura, F. (2019). Cambodia's energy poverty and its effects on social wellbeing: Empirical evidence and policy implications. *Energy Policy, 132 (1)*, 283-289. https://doi.org/10.1016/j.enpol.2019.05.032.

Zhang, L., Godil, D., Bibi, M., Khan, M., Sarwat, S., & Anser, M. (2021). Caring for the environment: How human capital, natural resources, and economic growth interact with environmental degradation in Pakistan? A dynamic ARDL approach. *Science of The Total Environment, 774*, 56-72.