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Article

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The Unsustainable Path: Assessing Indonesia's Reliance on Fossil Energy in Economic Growth

Sukanto Sukanto*, Azwardi Azwardi, Hamira Hamira, Dirta Pratama Atiyatna

Department of Development Economics, Faculty of Economics, Sriwijaya University, Indonesia. *Email: soekanto0813@fe.unsri.ac.id

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ABSTRACT

Indonesia is the most energy-intensive country in Southeast Asia. Indonesia's energy consumption reaches 40% of the total energy consumption in the Southeast Asian region. This study aims to analyze the relationship between economic growth and energy consumption in Indonesia in 2000-2021. The variables used are oil and gas GDP, energy consumption, global price, net exports and imports, foreign investment, and domestic investment. The data used is obtained from macroeconomic data and requires stationarity testing. This study uses a quantitative research type to assess energy consumption and its relationship with oil and gas GDP in Indonesia with the Auto-Regressive Distributed Lag (ARDL) Model Approach. The results of this study indicate that increasing development and dynamic economic growth will be accompanied by increasing energy demand. The conclusion of this study is that the ARDL model estimation results show significant differences in the influence of variables on oil and gas GDP in Indonesia in the short and long term.

Keywords: Energy Consumption, Oil and Gas GDP, Global Price, Net Export, Investment
JEL Classifications: E00, P48, Q43

1. INTRODUCTION

Energy is a fundamental driver of economic activities, serving as both an essential resource and a critical indicator of a country's developmental and economic progress (Chen et al., 2020; Guo, 2018). Policy frameworks around the world identify energy performance as a central pillar for achieving sustainable and inclusive economic growth (Lee and Woo, 2020; Aiyetan and Olomola, 2017).

From an economic perspective, the role of energy can be dissected into supply and demand aspects. On the demand side, consumers utilize energy as a direct commodity to enhance their utility. Conversely, the supply side views energy as an integral component of the production matrix, alongside capital, labor, and materials (Greene et al., 2020; Yao et al., 2019). This dual role underscores the significance of energy across various sectors including industry, transportation, households, and businesses. Consequently, burgeoning development intensifies energy demand and diversifies sources of state revenue (Rudenko and Tanasov, 2022; Heffron et al., 2020).

Given its importance, the development process cannot be separated from the development of the energy sector. Therefore, good energy planning is absolutely necessary to ensure the success of national development. Increasing development and dynamic economic growth, characterized by increasing production output and various other economic activities, will be accompanied by an increasing population, causing an increase in energy demand (Ministry of Energy and Mineral Resources, 2021; Surya et al., 2021; Nosheen et al., 2021).

In Southeast Asia, fossil energy demand is expected to surge by 80% by 2030, a rise from 76% in 2020. The industrial sector remains the primary consumer, with an average annual growth rate of 2.7% expected through 2035 (Shaari et al., 2020). These

emerging patterns underscore the critical need for a secure energy framework to support economic resilience in the region, calling for strong governance and financial systems (ASEAN Center for Energy, 2019).

Indonesia stands out as the region's largest consumer of energy in Southeast Asia, making up 40% of the area's total energy use (Fallin et al., 2023). Being a nation in the midst of development, its energy requirements—most notably in the industrial sector—are projected to escalate significantly. Forecasts suggest an average annual growth rate of 5.6% in the country's energy demand through 2035, with industry consuming 49%, followed by transportation at 29%, households at 15%, and other sectors including commerce, agriculture, and construction making up the remainder (Labandeira et al., 2020; ASEAN Center for Energy, 2017).

At present, Indonesia predominantly relies on non-renewable sources like petroleum, natural gas, and coal to meet its energy demands. These sources, however, are finite and will eventually fall short of fulfilling the country's growing energy requirements. A staggering 94-95% of the nation's primary energy comes from these fossil fuels, while renewable resources like hydro and geothermal power contribute only a meager 4-5% to the energy mix (IESR, 2022; ADB, 2020; Amir et al., 2019).

Empirical studies present mixed findings on the relationship between energy consumption and economic growth, including Ivanovski et al. (2021) and Al Khars et al. (2020) which state that energy consumption has a positive and statistically significant impact on economic growth. Likewise, Aldhshan et al. (2021) observed that electricity consumption is an important element that determines economic growth, as well as a powerful tool in executing government policies for energy savings in Malaysia. Chen et al. (2020) stated that energy has a complementary and substitution relationship with other production factors in creating output (GDP). Wesley Burnett and Madariaga (2017) state that increasing energy prices and increasing per capita income play a major role in reducing energy intensity in states in the United States. Munir et al. (2020) stated that energy conservation will not have much impact on economic growth.

Mutumba et al. (2021) in developed countries generally adhering to the Conservation hypothesis, they will not choose to increase energy consumption primarily to achieve economic growth, but rather because high GDP and maintaining larger development goals lead to an increase in energy consumed, therefore such economies can pursue clean energy goals, energy efficiency, and sustainable energy goals. Meanwhile, developing countries are endowed with a variety of energy resources that are technologically constrained to exploit optimally. Warsame (2022) oil prices asymmetrically affect economic growth in Somalia both in the short and long run. Positive oil price shocks have no effect in the long run but hinder economic growth in the short term, while negative oil price shocks have a constructive role in the long run but not in the short term. Umurzakov et al. (2020) economic growth positively affects energy consumption in post-communist countries. There is unidirectional causality from economic growth to energy consumption.

Marinaş et al. (2018) observed that in the short term, there is no significant correlation between Gross Domestic Product (GDP) and Renewable Energy Consumption (REC) in Romania and Bulgaria. However, in Hungary, Lithuania, and Slovenia, an uptick in renewable energy consumption is associated with an increase in economic growth. Fernandes and Reddy (2020) found that in India and Thailand, economic growth leads to higher energy consumption, which in turn poses economic and environmental challenges for both countries. Importantly, energy conservation policies are not shown to have a detrimental impact on economic growth. Jin and Kim (2018) discovered that coal consumption has a positive influence on short-term economic growth, but in the long term, it can have a negative impact. Excessive reliance on coal can hinder economic growth over time.

Several earlier studies have investigated the connection between energy consumption and economic growth. Nevertheless, a consensus has not been achieved to clearly outline how these variables are interrelated. This study's objective is to examine the influence between energy consumption and economic growth in Indonesia, considering both short-term and long-term perspectives.

2. RESEARCH METHOD

This study examines economic growth and energy consumption in Indonesia during the period 2000-2021. This study uses quantitative research to assess energy consumption and its relationship with oil and gas GDP in Indonesia using the Auto-Regressive Distributed Lag (ARDL) Model Approach. The variables used are oil and gas GDP, energy consumption, global price, net exports and imports, foreign investment, and domestic investment (Table 1).

Macroeconomic data generally has a unit root due to random trend data. In this case, it is necessary to test the stationarity of the data which is usually applied the Augmented Dickey Fuller (ADF) test. The test is related to the t-statistic of δ_2, the coefficient of which is presented in the following regression model:

$$\Delta z_t = \delta_0 + \delta_1 t + \delta_2 z_{t-1} + \sum_{i=1}^{n} n_i z_{t-1} + \varepsilon_t \quad (1)$$

In equation 1, it can be explained as a difference operation of order 1 with n number of lags. In addition, z is the time series contained in the study, t is the time period reflecting years, ε is the stationary random error associated with the autocorrelation adjustment. H_0 assumes Z_t is a nonstationary time series (has a unit root). In this case, the condition is tested:
H_0: $\delta_2 = 0$
H_1: $\delta_2 < 0$

To determine the optimal lag length, this study uses the Akaike Information Criteria (AIC). According to the rule of thumb, the model with the lowest AIC is good. In relation to the research model, the log-log model can generally be written as follows:

$$LPDB_t = \beta_1 + \beta_2 LKE_t + \beta_3 LGP_t + \beta_4 LNE_t + \beta_5 LPMA_t + \beta_5 LPMDN_t + \vartheta_t \quad (2)$$

Table 1: Operational definition of variables and data sources

No.	Variable	Definition	Unit	Data source
1	Oil and gas GDP	Gross Domestic Product or aggregate income from Oil and Gas	Billion Rupiah	Statistics Indonesia and World Bank
2	Energy consumption	Energy use for consumption and production activities of various economic sectors	Million Barrels	Ministry of Energy and Mineral Resources Republic of Indonesia
3	*Global price*	Global price of oil and gas	USD/barrel	Trading Economics and Ministry of Energy and Mineral Resources
4	Net exports	Net exports or exports minus imports	Billion Rupiah	Statistics Indonesia and World Bank
5	Foreign Investment	Investment in the mining and quarrying sector originating from abroad	Million Dollars	Ministry of Investment
6	Domestic Investment	Investment in the mining and quarrying sector originating from within the country	Billion Rupiah	Ministry of Investment

Where LPDB is log Gross Domestic Product of Oil and Gas, LKE is log Energy Consumption, LGP is log Global Price, LNE is log Net Export, LPMA is log Foreign Investment, LPMDN is Domestic Investment, ϑ is error term.

Furthermore, the ARDL error correction model (ECM) can be written as follows:

$$\begin{aligned}\Delta LPDB_t &= \beta_1 + \sum_{i=1}^{p1} \partial_1 \Delta LPDB_{t-i} + \sum_{j=1}^{q1} \rho_{1j} \Delta KE_{t-j} + \pi_1 KE_{t-1} \\ &+ \pi_1 LPDB_{t-1} + \sum_{j=1}^{q1} \rho_{1j} \Delta GP_{t-j} + \pi_2 GP_{t-1} \\ &+ \sum_{j=1}^{q1} \rho_{1j} \Delta NE_{t-j} + \pi_3 NE_{t-1} + \sum_{j=1}^{q1} \rho_{1j} \Delta PMA_{t-i} \\ &+ \pi_4 PMA_{t-1} + \sum_{j=1}^{q1} \rho_{1j} \Delta PMDN_{t-i} + \pi_5 PMDN_{t-1} + \vartheta_t \end{aligned} \quad (3)$$

The significance of all independent variables has been tested using the F-statistic. In the equation, ∂, ρ, π are the parameter estimates, p and q are the lag orders of the dependent and exogenous regressors, respectively. However, if the model has a unit root, then the cointegration relationship will be evaluated as follows:

$$\begin{aligned}\Delta LPDB_t &= \beta_2 + \sum_{i=1}^{p2} \partial_2 \Delta LPDB_{t-i} + \sum_{j=0}^{q2} \rho_{2j} \Delta KE_{t-j} \\ &+ \sum_{j=0}^{q2} \rho_{2j} \Delta GP_{t-j} + \sum_{j=0}^{q2} \rho_{2j} \Delta NE_{t-j} \\ &+ \sum_{j=0}^{q2} \rho_{2j} \Delta PMA_{t-i} + \sum_{j=0}^{q2} \rho_{2j} \Delta PMDN_{t-i} + \vartheta_{2t} \end{aligned} \quad (4)$$

$$\begin{aligned}\Delta LPDB_t &= \beta_3 + \sum_{i=1}^{p3} \partial_3 \Delta LPDB_{t-i} + \sum_{j=0}^{q3} \rho_{3j} \Delta KE_{t-j} \\ &+ \sum_{j=0}^{q3} \rho_{3j} \Delta GP_{t-j} + \sum_{j=0}^{q3} \rho_{3j} \Delta NE_{t-j} \\ &+ \sum_{j=0}^{q3} \rho_{3j} \Delta PMA_{t-i} + \sum_{j=0}^{q3} \rho_{3j} \Delta PMDN_{t-i} \\ &+ \delta \varepsilon_{t-1} + \vartheta_{3t} \end{aligned} \quad (5)$$

In the above equation, the variable of δ is the error coefficient of the corrected model. If it has a negative sign then it implies the speed of convergence towards equilibrium.

3. RESULTS AND DISCUSSION

Stationarity tests were performed using the Augmented Dickey-Fuller (ADF) Fisher Chi-square test, following the necessary steps in time series econometric analysis. The precondition for employing the Auto-Regressive Distributed Lag (ARDL) method is that the data should exhibit stationarity either at the original level or after first differencing.

The Schwarz-Bayesian Criterion (SBC) is employed to ascertain the optimal lag order to be incorporated into the infinite error correction model. Its objective is to confirm the absence of indications of serial correlation or instability within the model, aligning with the recommendation by Shin and Pesaran (1999) advocating for a minimum lag length of two. The outcomes of the Augmented Dickey-Fuller (ADF) unit root test conducted in this study reveal that all variables exhibit stationarity, either in their original form or after first differencing (Table 2).

The estimation results of the ARDL model show that there are significant differences in the influence of variables on oil and gas GDP in Indonesia in the short term and long term. In the short run, the variables of Energy Consumption, Global Price, Net Export, foreign investment, and domestic investment have a significant influence on oil and gas GDP in Indonesia. However, it should be noted that foreign investment (FDI) has a negative impact in the short term. This may be due to fluctuations in foreign investment that may destabilize the economy in a short period (Table 3).

However, in the long run, the pattern of influence changes. Energy Consumption still has a positive effect, which may indicate that sustained high energy consumption can support the growth of oil and gas GDP in the long run. On the other hand, Global Price, Net Export, and Domestic Investment have a negative effect in the long run (Table 3). This may reflect the long-term challenges faced by the oil and gas sector in Indonesia. The negative effect of Global Price can be understood as the impact of fluctuations in world oil prices which can be detrimental to producing countries such as Indonesia in the long run. Net Exports having a negative influence in the long run may indicate that over-reliance on oil and gas exports may become an economic vulnerability in the long run. In addition, the negative effect of Domestic Investment in the long run may indicate the need for policies that support sustainable domestic investment to maintain the growth of the oil and gas sector in the future.

This study is consistent with previous literature such as Ivanovski et al. (2021) and Al Khars et al. (2020) which state that energy consumption has a positive and statistically significant impact on economic growth. Likewise, Umurzakov et al. (2020) which states that economic growth positively affects energy consumption in Post-Communist countries. There is unidirectional causality from economic growth to energy consumption. These findings are also in line with a study conducted by Lin and Moubarak (2014) which confirmed the negative impact of energy prices on energy intensity in China in the period 1985 to 2010. Elfaki et al. (2021) industrialization, financial sector growth, and energy consumption play a pivotal role in attaining enduring and sustainable economic expansion in Indonesia. Adom (2015) also found that there is a negative relationship between the effect of crude oil prices on energy intensity. A similar study was also conducted by Ibrahim (2011) who analyzed the relationship between energy consumption, real income, and energy prices in Saudi Arabia using annual data for the time period 1982 to 2007. Real income and energy consumption affect energy prices, while energy prices do not affect real income or energy consumption.

Table 2: Unit root tests

Variables	ADF Fisher-Chi-square			
	Levels		First difference	
	Intercept	Trend	Intercept	Trend
$LPDB_t$	−0.4381	−1.9212	−4.3975***	−4.4159***
LKE_t	−1.2132	−1.9213	−3.9624***	−3.8547***
LGP_t	−1.5462	−0.9187	−3.0670***	−3.9004***
LNE_t	−3.2365***	−3.4342***	−6.2903***	−6.0941***
$LPMA_t$	−2.7980***	−2.8880**	−7.6131***	−2.7413***
$LPMDN_t$	−2.6383***	−4.0409***	−7.3223***	−7.0706***

Source: Author's own calculations. Where *** indicates 1%, ** 5% significance level, * 10% significance level

Table 3: Long-run and short-run model

Variables	Coefficient	Std. Error	t-Statistic	Prob.*
Long run equation				
LKE	9.921145	1.518385	6.534010	0.0226
LGP	−2.131264	0.182406	−11.68417	0.0072
LNE	−0.888629	0.137047	−6.484113	0.0230
LPMA	0.134867	0.138587	0.973160	0.4331
LPMDN	−0.887221	0.096264	−9.216535	0.0116
Short Run Equation				
COINTEQ(−1)*	−1.571763	0.133322	−11.78922	0.0071
D (LKE)	8.892214	0.748492	11.88017	0.0070
D (LKE(−1))	−3.477547	0.570508	−6.095523	0.0259
D (LGP)	−0.521986	0.095703	−5.454209	0.0320
D (LGP(−1))	1.906866	0.219088	8.703659	0.0129
D (LNE)	−0.180319	0.036030	−5.004710	0.0377
D (LNE(−1))	0.285658	0.054404	5.250653	0.0344
D (LPMA)	−0.166339	0.036783	−4.522230	0.0456
D (LPMA(−1))	−0.066263	0.027261	−2.430671	0.1357
D (LPMDN)	−0.317848	0.029409	−10.80778	0.0085
D (LPMDN(−1))	0.459080	0.056966	8.058880	0.0151
C	−85.50912	18.81578	−4.544542	0.0452

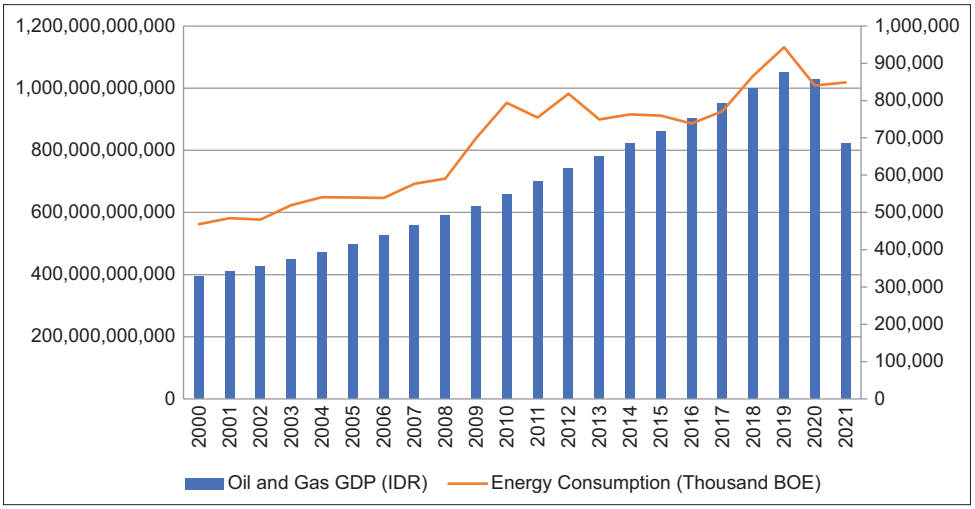
Source: Author's own calculations. *P values and any subsequent tests do not account for model selection

First of all, it can be seen from the data that the GDP of the Oil and Gas sector has increased significantly from 2000 to 2019, reaching more than 1 trillion IDR in 2019. This reflects the large contribution of this sector to the Indonesian economy over the period. Furthermore, there were fluctuations in Energy Consumption over the same period. Despite the year-on-year increase, there was a sharp decline in Energy Consumption in 2020 and 2021, while the Oil and Gas sector GDP also experienced a significant decline in 2021 due to the COVID-19 pandemic. There is a positive correlation between Oil and Gas GDP and Energy Consumption (Figure 1).

Energy is indispensable in carrying out Indonesia's economic activities, both for consumption needs and for production activities of various economic sectors. As a natural resource, energy must be utilized to the greatest extent for the prosperity of society and its management must refer to the principles of sustainable development. In terms of supply, Indonesia is a country rich in energy resources, both unrenewable and renewable resources. However, the exploration of energy resources is more focused on fossil energy which is unrenewable resources while renewable energy is relatively not widely utilized (Akadiri et al., 2019).

This condition causes the availability of fossil energy, especially crude oil, to become increasingly scarce, which has caused

Figure 1: Oil and Gas GDP dan energy consumption in Indonesia 2000-2021



Source: Ministry of Energy and Mineral Resources, 2021

Indonesia to become a net importer of crude oil and its derivative products. Energy plays an important and crucial role in economic growth as it is understood as the main source in the country's production and manufacturing sectors. Therefore, energy-related policies and regulations are crucial in understanding the link between economic growth and energy consumption (Munir et al., 2020).

The positive correlation between Oil and Gas sector GDP and energy consumption shows how important the energy sector is in supporting Indonesia's economic growth. However, a challenge that Indonesia faces is the dependence on fossil energy, especially oil, which is imported. In the long run, this can be an economic risk as fluctuations in world oil prices can affect the country's economic stability. Therefore, wise policies and regulations are needed in managing Indonesia's energy resources. One of them is the diversification of energy sources to reduce dependence on fossil energy and encourage the use of renewable energy. In addition, there is a need to invest in improving energy efficiency to reduce energy consumption per unit of GDP. Thus, Indonesia can achieve sustainable economic growth while maintaining environmental sustainability and the availability of energy resources.

4. CONCLUSION

The estimation results of the ARDL model show significant differences in the influence of variables on oil and gas GDP in Indonesia in the short term and long term. In the short run, variables such as Energy Consumption, Global Price, Net Export, foreign investment, and domestic investment have a significant influence on Oil and Gas GDP. However, it should be noted that foreign direct investment (FDI) has a negative impact in the short term, which may be due to fluctuations in foreign investment that can destabilize the economy in a short period.

On the other hand, in the long run, the pattern of influence changes. Energy Consumption still has a positive effect, indicating that sustained high energy consumption can support the growth of oil and gas GDP in the long run. However, Global Price, Net Export, and Domestic Investment have a negative effect in the long run, reflecting the long-term challenges faced by the oil and gas sector in Indonesia, including fluctuations in world oil prices and dependence on oil and gas exports.

From these results, policy implications that can be considered are improving energy efficiency to reduce dependence on energy consumption in the long run. In addition, economic diversification to reduce dependence on the oil and gas sector, as well as efforts to increase sustainable domestic investment, can help address economic vulnerabilities in the long run. Efforts to manage fluctuations in world oil prices and reduce dependence on oil and gas exports are also important factors in maintaining long-term economic stability. The importance of utilizing sustainable energy resources, including renewable energy, should also be a focus in future energy policy planning. Thus, the government can formulate policies that support sustainable economic growth and reduce the risks associated with the oil and gas sector in Indonesia.

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