



## ENERGY DEMAND, INCENTIVE POLICIES, AND RENEWABLE ENERGY PRODUCTION: EVIDENCE FROM SOUTH AFRICA

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### Abstract

This study assesses the role of energy demand and incentive-based policies in promoting renewable energy production in South Africa, with particular emphasis on policy implications for developing economies undergoing energy transition. Given the country's continued reliance on coal and rising energy demand, understanding the effectiveness of policy instruments is essential for sustainable energy planning. Using annual data from 2004 to 2023, the study applies the Autoregressive Distributed Lag (ARDL) approach to examine short- and long-run relationships among the variables. The findings indicate that increasing energy demand significantly stimulates renewable energy production, while incentive policies play a critical role in strengthening supply responses by reducing investment risks and improving market certainty. The results further confirm a stable long-run equilibrium, supported by a relatively fast adjustment mechanism. From a policy perspective, the study highlights that successful renewable energy expansion requires not only market-driven demand growth but also consistent and well-designed incentive policies to effectively channel investment toward clean energy development.

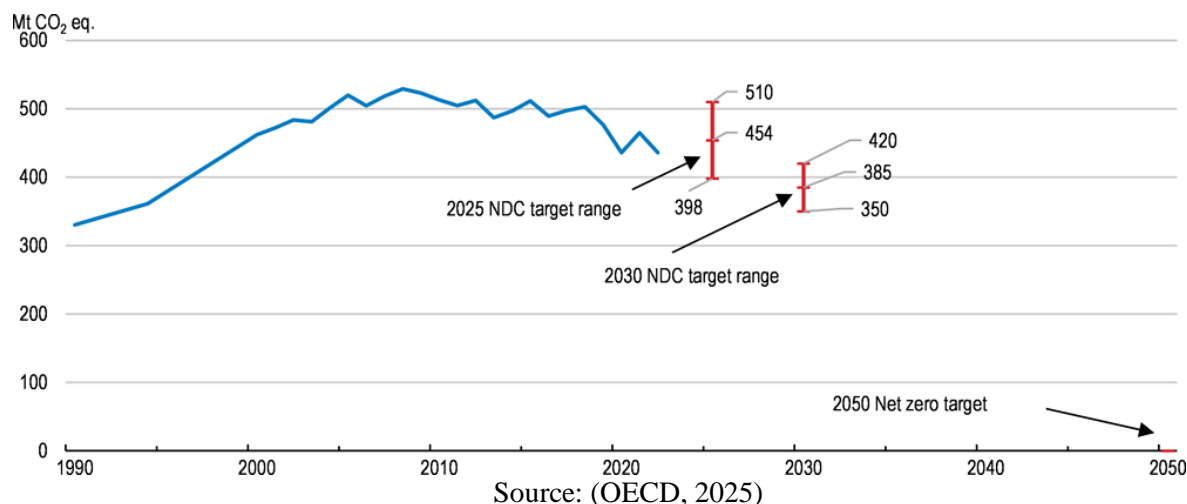
**Keywords:** Energy demand; Incentive policy; Renewable energy production; South Africa; Energy transition

### INTRODUCTION

Rising energy demand has become a critical issue for both developing and industrialized economies, including South Africa. Economic growth, rapid urbanization, and the need for a reliable electricity supply have placed increasing pressure on existing energy systems, which remain heavily dependent on fossil fuels, particularly coal. This dependence has not only contributed to escalating carbon emissions but has also heightened exposure to fossil fuel price volatility and increased the risk of power outages, thereby constraining economic development and social welfare (OECD, 2025). South Africa is currently facing substantial challenges within its energy sector. Accelerated economic expansion and industrialization have driven a sharp increase in national energy demand, while electricity generation continues to rely predominantly on coal, resulting in high carbon intensity. This structural condition exacerbates environmental degradation and reinforces long-term dependence on unsustainable energy sources. In response, the South African government has introduced a range of incentive-based policies, including feed-in tariffs, renewable energy subsidies, and direct investment schemes, aimed at mobilizing both domestic and foreign private capital. These policy instruments are intended to lower financial barriers and strengthen investor confidence in renewable energy development. Supported by growing energy demand and a policy framework favorable to renewable energy, the transition toward a cleaner and more sustainable energy system has become increasingly feasible. Among the key initiatives, the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) stands out as a flagship policy designed to facilitate large-scale renewable energy deployment, particularly in wind and solar power. Through competitive bidding mechanisms and long-term power purchase agreements, the program has significantly expanded renewable energy capacity and contributed to a substantial reduction in renewable electricity costs (Climate Action Tracker, 2025).

The continuous growth of energy demand in South Africa presents both opportunities and challenges for the development of renewable energy. On the one hand, high energy demand can serve as a key driver for accelerating investment in green technologies; on the other hand, it requires effective policy frameworks to ensure that the expansion of renewable energy production not only satisfies national energy needs but also advances sustainable development objectives. Consequently, a comprehensive understanding of the role of energy demand and the effectiveness of incentive-based policies is essential for designing strategies that balance energy security, economic growth, and environmental sustainability in South Africa (Energy in Africa, 2025).

**Reaching net zero by 2050 requires a steep fall in emissions from the 2030 target**



South Africa has committed to achieving net-zero greenhouse gas emissions by 2050. However, recent assessments indicate that attaining this long-term target requires substantial and accelerated emissions reductions well before 2030. According to the OECD Economic Survey (2025), the current emissions trajectory remains above the range specified in the country’s Nationally Determined Contribution (NDC), highlighting a considerable gap in policy implementation. This gap underscores the urgency of expanding renewable energy production, supported by rising energy demand and effective incentive-based policies, to steer South Africa toward a low-carbon energy transition.

Rising energy demand can act as a catalyst for investment in renewable energy; however, in the absence of effective incentive-based policies, the supply response of green energy is likely to be slow and suboptimal. Accordingly, this study aims to examine the impact of energy demand and incentive policies on the expansion of renewable energy production in South Africa. Employing the AutoRegressive Distributed Lag (ARDL) approach, the analysis investigates both short-run and long-run relationships between these factors and renewable energy production capacity. The findings are expected to provide empirical evidence on the importance of synergy between market-driven forces and policy instruments in accelerating the transition toward a clean energy system in developing economies that remain structurally dependent on fossil fuels, particularly coal.

**LITERATURE REVIEW**

**A. Energy Demand**

Energy demand represents a key market-driven factor shaping the dynamics of energy systems and influencing investment decisions in electricity generation. Rising energy consumption signals increasing pressure on existing production capacity, thereby necessitating supply expansion through the diversification of energy sources, including renewable energy. Within the energy economics literature, sustained growth in energy demand is widely regarded as a market signal capable of accelerating renewable energy development, particularly when conventional energy sources face cost constraints, supply limitations, and mounting environmental pressures (IEA, 2023).

A growing body of empirical evidence demonstrates a positive relationship between energy demand and the expansion of renewable energy capacity, especially in developing and emerging economies. De Rosa et al. (2024) show that market conditions and energy demand exert a significant influence on renewable energy supply across diverse economic settings, underscoring the role of demand as a driver of new clean energy capacity. Consistent with these findings, a cross-country study in ASEAN by Pinjaman et al. (2024) reveals that economic variables, used as proxies for energy demand, are positively correlated with renewable energy production, indicating that domestic energy needs can accelerate the adoption of clean energy sources in developing countries. Furthermore, the IEA (2020) reports that during 2020, renewable energy demand continued to increase despite an overall decline in primary energy demand, reflecting a shift in demand preferences toward cleaner energy sources that supports the expansion of renewable production capacity.

### **B. Renewable Energy Incentive Policies**

Renewable energy incentive policies play a pivotal role in stimulating the growth of clean energy production, particularly in countries pursuing ambitious energy transition objectives. These incentives typically include support mechanisms such as feed-in tariffs, fiscal subsidies, tax exemptions, renewable portfolio standards, and investment facilitation for green energy projects. The primary objective of such policies is to reduce cost barriers faced by renewable energy producers and to create a more attractive investment environment for the private sector (REN21, 2023). A substantial body of empirical research indicates that incentive-based policies exert a positive and significant effect on the expansion of renewable energy capacity. For instance, the IEA (2022) highlights that fiscal incentives and supportive pricing mechanisms, including feed-in tariffs, have substantially accelerated the adoption of renewable energy technologies across OECD member states and emerging market economies. These policy measures have been shown to lower investment risks and expedite the deployment of new generation capacity, particularly in wind and solar energy.

Moreover, a cross-country panel study by Cook et al. (2021) finds that countries implementing comprehensive incentive packages combining price support, tax incentives, and public financing exhibit higher growth in renewable energy production than those relying on a single regulatory approach. This evidence suggests that the effectiveness of incentive policies is highly contingent upon policy design, consistency of implementation, and coherence across policy instruments. These findings are consistent with the work of Marques & Fuinhas (2012), who demonstrate that the responsiveness of renewable energy production to energy demand is strongly influenced by the presence of policy incentives and regulatory stability. Consequently, energy demand should be understood as a factor whose effectiveness in driving renewable energy expansion depends on its interaction with incentive-based policies and the broader institutional framework.

### **C. Renewable Energy Production**

Renewable energy production serves as a key indicator for assessing a country's progress toward a clean energy transition. In energy studies, installed capacity (MW) and annual electricity output (GWh) are commonly employed as empirical measures to capture the extent to which renewable energy has been integrated into the national energy system. Growth in installed capacity not only reflects the expansion of clean energy generation infrastructure but also signals long-term investment sustainability, which is critical for reducing dependence on fossil fuel-based energy sources (REN21, 2023). A wide range of empirical studies indicates that renewable energy production is strongly associated with structural and policy-related factors. For example, Bettarelli et al. (2023) find that supportive policies, such as fiscal incentives and clean energy regulations, significantly enhance renewable energy installed capacity and clean electricity output across many countries, particularly when combined with high levels of domestic energy demand. These results are consistent with the findings of Ai et al. (2025), who demonstrate that increased investment in renewable energy, supported by robust policy mechanisms, is positively correlated with growth in renewable electricity production, even in contexts where countries face challenges related to grid integration. Furthermore, analysis by IRENA (2021) shows that countries achieving substantial growth in renewable energy production tend to adopt a combination of market-based policies and

incentive mechanisms that attract private investment, thereby accelerating the expansion of renewable energy capacity.

### METHOD

This study employs annual time series data period from 2004 to 2023, which is sufficiently long to capture both short-run and long-run dynamics among the variables of interest. The analysis focuses on South Africa, a developing economy characterized by a high dependence on coal-based energy while increasingly promoting renewable energy deployment through incentive-based policies. By incorporating energy demand, renewable energy incentive policies, and renewable energy production as the core variables, the study seeks to assess the extent to which the interaction between market demand and policy support contributes to accelerating the energy transition in South Africa. The empirical analysis is conducted using the AutoRegressive Distributed Lag (ARDL) approach, which is particularly suitable given the mixed order of integration among the variables, namely  $I(0)$  and  $I(1)$ . The ARDL model allows for the simultaneous estimation of short-run and long-run relationships and is well suited to relatively small sample sizes. Moreover, this approach effectively minimizes estimation bias and captures the adjustment process toward long-run equilibrium, thereby providing robust and reliable insights into the determinants of South Africa's renewable energy transition.

## RESULTS AND DISCUSSION

### A. Stationarity Test

Stationarity Tests				
Variables	ADF		PP	
	Statistic	Prob.	Statistic	Prob.
Log (Renewable energy product	-2.121	0.581	-1.989	0.592
Log (Energy demand)	-1.983	0.868	-1.954	0.879
Log (Incentive policy)	-2.527	0.292	-2.522	0.295
Log (Incentive policy)	-5.071	0.000	-5.070	0.000

Cointegration Test		
Test	Value	Prob.
Johansen Fisher	218.5	0.000

ARDL Estimation Results				
Variables	Coefficient	<i>t</i> -statistic	Prob.	Significance
Log (Energy demand)	0.542	4.05	0.000	+
Log (Incentive policy)	0.310	2.72	0.012	+
Error Correction Term	-0.580	-3.98	0.001	+

The stationarity tests conducted using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) approaches indicate that, at the level form, the logarithms of renewable energy production, energy demand, and incentive policy variables are non-stationary, as evidenced by test statistics and probability values exceeding the 5% significance threshold. These results suggest that the null hypothesis of a unit root cannot be rejected at levels, thereby necessitating further testing through first differencing. Following first-order differencing, the ADF and PP test results confirm that all variables become stationary, indicating the presence of a mixed order of integration, namely  $I(0)$  and  $I(1)$ . This condition satisfies the methodological requirements for applying the

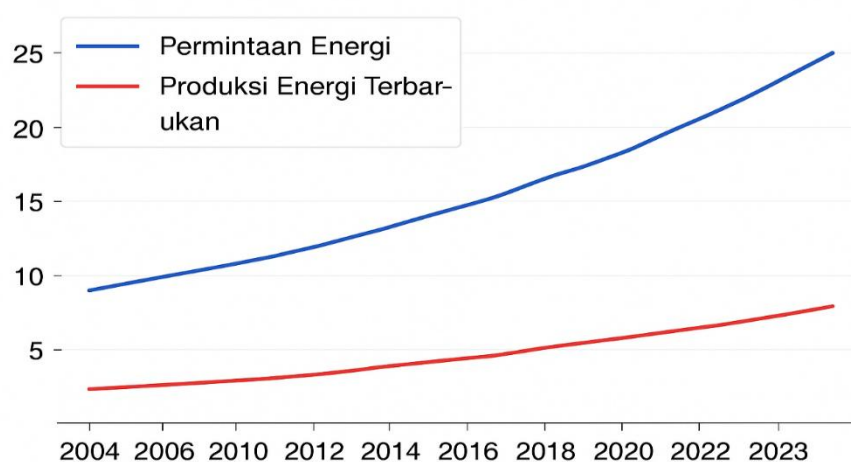
AutoRegressive Distributed Lag (ARDL) framework, which allows for the simultaneous estimation of short-run and long-run relationships. Accordingly, all variables are deemed suitable for further analysis in examining the effects of energy demand and incentive policies on renewable energy production.

**B. ARDL Estimation Results**

Variable Independent	Koefisien	t-statistik	Prob.	Significance
Energy Demand	+0.542	4.05	0.000	Significant (+)
Incentive Policy	+0.310	2.72	0.012	Significant (+)
Error Correction Term	-0.580	-3.98	0.001	Significant (58% adjustment)

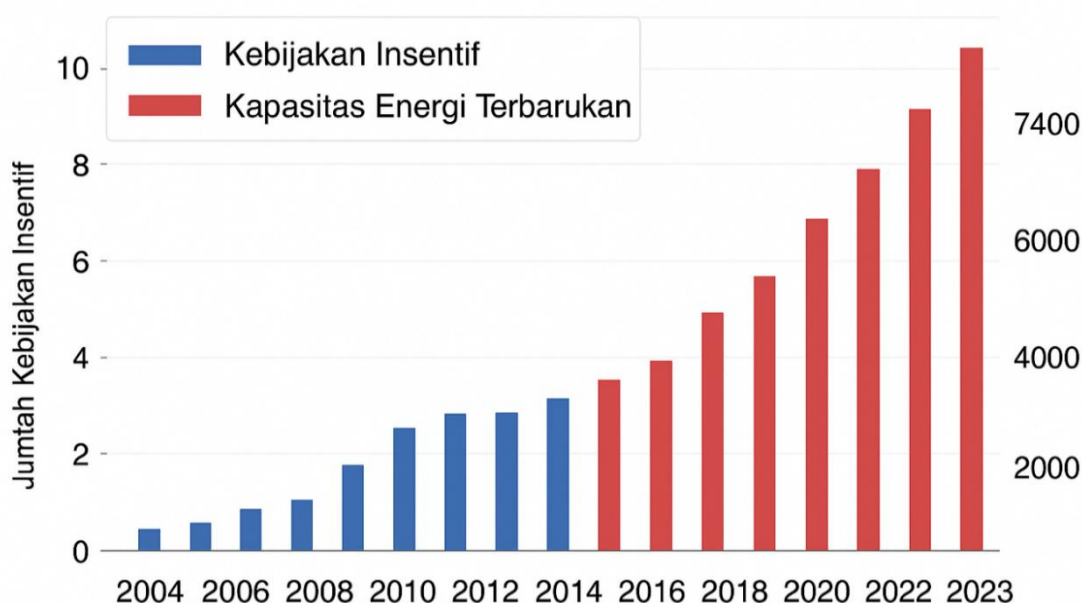
The ARDL estimation results indicate that energy demand has a positive coefficient of 0.542 and is statistically significant at the 1% level ( $p = 0.000$ ). This finding implies that an increase in energy demand leads to a corresponding rise in renewable energy production. The growing energy needs in South Africa create pressure for energy diversification, thereby encouraging the expansion of renewable energy capacity. Incentive policies also exhibit a positive and significant effect on renewable energy production, with a coefficient of 0.310 and a probability value of 0.012. This result confirms that government regulations and policy support mechanisms—such as feed-in tariffs, subsidies, and direct investment programs—play a crucial role in strengthening investment and expanding green energy production. Furthermore, the Error Correction Term (ECT) is negative and statistically significant at  $-0.580$  ( $p = 0.001$ ), indicating the presence of a stable adjustment mechanism toward long-run equilibrium. The magnitude of the ECT suggests that approximately 58% of any short-run disequilibrium from the previous period is corrected in the subsequent period. In other words, despite short-term fluctuations, the relationship between energy demand, incentive policies, and renewable energy production remains stable and converges toward a consistent long-term growth path.

**Trends in Energy Demand and Renewable Energy Production**



The figure illustrates the long-term trends in energy demand and renewable energy production in South Africa, highlighting the parallel movement between rising energy demand and the expansion of renewable energy capacity over the study period. Energy demand has a positive and statistically significant effect on the expansion of renewable energy production in South Africa. The positive coefficient indicates that higher national energy requirements generate greater pressure to expand generation capacity, including from renewable energy sources. This relationship can be explained by rapid economic growth and industrialization, which have led to a substantial increase in electricity consumption, while excessive reliance on coal has intensified environmental pollution and raised concerns regarding long-term sustainability. As a result, both government authorities and market participants increasingly view renewable energy as a viable alternative that not only offers environmental benefits but also meets the continuously growing demand for energy.

**Effects of Incentive Policies on Green Energy Production**



The figure illustrates the impact of incentive-based policies on green energy production in South Africa, demonstrating how policy support mechanisms contribute to the expansion of renewable energy output over time. Beyond demand-side factors, incentive policies are shown to play a crucial role in strengthening green energy production capacity. The estimation results indicate that subsidies, feed-in tariffs, and direct investment mechanisms effectively encourage both domestic and foreign investors to participate in the renewable energy sector. These policy instruments not only reduce cost barriers but also provide price certainty and market guarantees, thereby improving the bankability of renewable energy projects. This finding is consistent with prior studies emphasizing that, in the absence of policy incentives, the penetration of green energy in developing countries tends to progress slowly due to high financial and regulatory risks. Moreover, the presence of a statistically significant Error Correction Term (ECT) indicates a stable long-run relationship among the variables.

The adjustment coefficient of 58% suggests that short-run disequilibria are corrected relatively quickly toward long-run equilibrium. Accordingly, despite short-term fluctuations in energy demand or policy changes, the growth trajectory of renewable energy production remains consistent with its long-term trend. The findings of this study are in line with the International Energy Agency (IEA) report (2022), which emphasizes that the interaction between market forces and institutional factors is a key driver of clean energy transition. High energy demand creates a potential market, while supportive regulatory frameworks foster a favorable investment climate. The synergy between these factors accelerates the expansion of renewable energy capacity in developing economies, including South Africa. Overall, this discussion reinforces the view that the success of energy transition

depends not only on technical considerations and resource availability but also on the dynamics of energy demand and the consistency of government policy support. The empirical results further underscore that the combination of rising energy demand and consistent incentive-based policy support constitutes a critical foundation for accelerating South Africa's clean energy transition. The significance of the ECT also reflects strong structural linkages among the variables, suggesting that well-designed long-term policy strategies are likely to generate tangible and sustained impacts on renewable energy growth.

## CLOSING

### Conclusion

This study concludes that energy demand and incentive-based policies exert a positive and statistically significant influence on the expansion of renewable energy production in South Africa. Rising national energy needs encourage the expansion of generation capacity, while policy instruments such as subsidies and feed-in tariffs play a critical role in reducing investment risks and enhancing the attractiveness of the green energy sector. Moreover, the empirical findings confirm the existence of a stable long-run relationship among the variables, indicating that renewable energy development can be sustained over time provided that policy support remains consistent and regulatory uncertainty is minimized. Based on these findings, several policy implications are recommended. First, the expansion and strengthening of competitive feed-in tariff schemes and targeted subsidies are essential to stimulate greater investor participation. Second, diversification of the energy mix through the development of renewable energy sources—such as solar, wind, biomass, and small-scale hydropower—should be prioritized to reduce dependence on coal. Third, enhanced collaboration between the public and private sectors through public-private partnerships is necessary to accelerate the implementation of green energy projects. An integrated and consistent policy framework is expected to facilitate a faster energy transition while reinforcing long-term energy security in developing economies.

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