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**THE MODERATING ROLE OF GOVERNANCE IN SOUTH AFRICA'S  
RENEWABLE ENERGY TRANSITION: IMPACTS ON SOCIAL INCLUSION**

**Abstract.** *This study examines the role of governance in South Africa's transition to renewable energy and its impact on social inclusion, contributing to the existing literature by situating this relationship within the theoretical framework of Transition Management Theory (TMT). Annual time-series data for the period 1990–2025 are analysed using the Autoregressive Distributed Lag (ARDL) approach to estimate both short-run and long-run dynamics. Results suggest that the transition to renewable energy has an insignificant but positive impact on social inclusion in the short run. The long-run estimates, however, indicate a negative impact, as coal-mining towns, communities dependent on natural gas and other fossil-fuel extraction, and workers employed in fossil-fuel-related industries face disproportionate socioeconomic costs from the phase-out of fossil fuels. Without proper governance measures — such as just transition frameworks, skills-transition programmes, social protection policies and targeted job-creation policies — the shift to renewable energy risks deepening existing inequalities. These findings provide empirical evidence that governance significantly moderates this relationship by improving institutional capacity, coordination, stakeholder engagement and the equitable distribution of renewable energy rents. Policymakers should therefore prioritise governance systems — supported by well-designed transition policies — that steer the renewable energy transition in ways that are environmentally sustainable, economically transformative and socially inclusive. In particular, the findings offer practical guidance for policymakers engaged in the Just Energy Transition (JET) Partnership on strengthening institutional capacity so that decarbonisation does not deepen existing socio-economic inequalities. Overall, the study offers new insights into the relationship between governance, renewable energy and social*



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inclusion in South Africa, and concludes that strong institutions are critical to managing the social risks of the transition to green energy while securing its benefits for inclusive development.

**Keywords:** Alternative Energy, Climate Change, Economic Development, Government Policy, Inequality and Justice.

**JEL Classification:** Q42, Q54, O13, Q48, D63

**Анотація.** Дане дослідження аналізує роль врядування в переході Південної Африки до відновлюваної енергетики та його вплив на соціальну інклюзію, роблячи внесок у наявну літературу шляхом розгляду цього взаємозв'язку в межах теоретичної рамки Теорії управління переходом (Transition Management Theory, TMT). Річні часові ряди даних за період 1990–2025 рр. проаналізовано за допомогою підходу авторегресії з розподіленими лагами (ARDL) для оцінки як короткострокової, так і довгострокової динаміки. Результати свідчать, що перехід до відновлюваної енергетики має незначущий, але позитивний вплив на соціальну інклюзію в короткостроковому періоді. Довгострокові оцінки, натомість, вказують на негативний вплив, оскільки вугледобувні містечка, громади, залежні від видобутку природного газу та інших викопних енергоресурсів, а також працівники галузей, пов'язаних із викопним паливом, стикаються з непропорційними соціально-економічними витратами внаслідок поступової відмови від викопного палива. За відсутності належних заходів врядування — таких як механізми справедливого переходу, програми перекваліфікації, політика соціального захисту та цільові заходи зі створення робочих місць — перехід до відновлюваної енергетики ризикує поглибити наявну нерівність. Ці результати надають емпіричні докази того, що врядування суттєво модерує цей взаємозв'язок шляхом покращення інституційної спроможності, координації, залучення заінтересованих сторін та справедливого розподілу рентних доходів від відновлюваної енергетики. Особам, які формують політику, відтак слід надавати пріоритет системам врядування — підкріпленим належно розробленою перехідною політикою, — які скеровують енергетичний перехід у спосіб, що є екологічно стійким, економічно трансформаційним і соціально інклюзивним. Зокрема, отримані результати можуть слугувати практичним орієнтиром для осіб, які формують політику в межах Партнерства заради справедливого енергетичного переходу (Just Energy Transition, JET), щодо зміцнення інституційної спроможності, аби декарбонізація не поглиблювала наявну соціально-економічну нерівність. Загалом дослідження пропонує нові підходи до розуміння взаємозв'язку між врядуванням, відновлюваною енергетикою та соціальною інклюзією в Південній Африці й робить висновок, що сильні інституції є критично важливими для управління соціальними ризиками переходу до зеленої енергетики, водночас забезпечуючи реалізацію її переваг для інклюзивного розвитку.

**Ключові слова:** альтернативна енергетика, економічний розвиток, зміна клімату, нерівність та справедливість, урядова політика.

**Absztrakt.** Jelen kutatás a kormányzás szerepét vizsgálja Dél-Afrika megújuló energiára való átállásában és annak a társadalmi inklúzióra gyakorolt hatásában, hozzájárulva a meglévő szakirodalomhoz azáltal, hogy ezt az összefüggést az Átmenetmenedzsment-elmélet (Transition Management Theory, TMT) elméleti keretében vizsgálja. Az 1990–2025 közötti időszak éves idősoros adatait autoregresszív elosztott késleltetésű (ARDL) megközelítéssel elemezték mind a rövid, mind a hosszú távú dinamika értékelése érdekében. Az eredmények azt mutatják, hogy a megújuló energiára történő átállás rövid távon statisztikailag nem szignifikáns, ugyanakkor pozitív hatást gyakorol a társadalmi inklúzióra. A hosszú távú becslések ezzel szemben negatív hatást jeleznek, mivel a szénbányászati települések, a földgáz- és egyéb fosszilis energiahordozók kitermelésétől függő közösségek, valamint a fosszilis tüzelőanyagokhoz kapcsolódó ágazatok munkavállalói aránytalanul magas társadalmi-gazdasági költségekkel szembesülnek a fosszilis tüzelőanyagok fokozatos kivezetése



következtében. Megfelelő kormányzati intézkedések — például az igazságos átmenetet biztosító mechanizmusok, átképzési programok, szociális védelmi politikák és célzott munkahelyteremtési intézkedések — nélkül a megújuló energiára történő áttérés fokozhatja a meglévő egyenlőtlenségeket. Az eredmények empirikus bizonyítékot szolgáltatnak arra, hogy a kormányzás jelentős mértékben moderálja ezt az összefüggést az intézményi kapacitás, a koordináció, az érdekelt bevonása, valamint a megújuló energiából származó járadékbevételek méltányos elosztásának javítása révén. A szakpolitikai döntéshozóknak ezért prioritásként kell kezelniük az olyan — jól megtervezett átmeneti szakpolitikákkal alátámasztott — kormányzati rendszerek kialakítását, amelyek környezeti szempontból fenntartható, gazdasági szempontból transzformatív és társadalmi szempontból inkluzív módon irányítják az energetikai átmenetet. Az eredmények különösen hasznos gyakorlati útmutatást nyújtanak az Igazságos Energetikai Átmenet (Just Energy Transition, JET) Partnerségben részt vevő döntéshozók számára az intézményi kapacitás erősítéséhez, hogy a dekarbonizáció ne mélyítse tovább a meglévő társadalmi-gazdasági egyenlőtlenségeket. Összességében a kutatás új megközelítésekkel járul hozzá a kormányzás, a megújuló energia és a társadalmi inklúzió közötti összefüggés megértéséhez Dél-Afrikában, és megállapítja, hogy az erős intézmények kritikus jelentőségűek a zöldenergia-átmenet társadalmi kockázatainak kezelésében, miközben biztosítják annak előnyeit az inkluzív fejlődés számára..

**Kulcsszavak:** alternatív energia, gazdasági fejlődés, éghajlatváltozás, egyenlőtlenség és igazságosság, kormányzati politika.

**Problem description.** It is a common knowledge that energy generated from fossil fuels (oil, coal and natural gas) is responsible for the emission of greenhouse gases observed today. Energy use worldwide gets about 80% from fossil fuels. Africa uses fossil fuels at a much higher percentage than the world average. Africa consumed fossil fuels at 94.5% of total energy supply (TES) and hydrocarbons (oil and gas) at 74% of TES. Compared to the world's average of 33% and 31% respectively, Africa continues to consume energy from fossil fuels at this high of a percentage due to many countries contributions, especially South Africa, being very dependent on fossil fuels for growth [2].

South Africa is one of the largest coal producers in southern Africa if not the largest producer in the region. Coal affords South Africa energy security while allowing for economic growth. Energy security afforded by coal must now be weighed with Paris Agreement commitments. As South Africa has signed the Paris Agreement, they must now balance this energy security while moving towards decarbonisation. The Paris Agreement aims to limit the increase in global temperatures by emitting fewer greenhouse gases into the atmosphere. The Paris Agreement has become one of the largest driving forces behind energy policy in many countries. Transitioning from fossil fuels may be difficult for South Africa. This difficulty might stem from South Africa's current infrastructure, dependence on coal power, ageing power plants, continuous load shedding, and no qualified persons to build new capacity [27]. South Africa has been one of the leading pioneers of renewable energy development in Africa. The country had an installed capacity of renewable energy projects at 13,355 MW by 2023. This expansion can be attributed to programs such as the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) and the Integrated Resource Plan (IRP). South Africa has invested \$135.6 billion USD into

renewable energy. 25.8% of these investments were foreign investors. Even with Africa's leading position in renewable energy, renewable energy only account for less than 10% of total power generation, showing just how deeply coal is rooted in South Africa's energy system.

The country has enacted policy reform in an attempt to fast-track the transition process. South Africa updated its Nationally Determined Contribution (NDC) in September 2021. Moving to a steep decarbonisation trajectory of 17% by 2025 and 32% by 2030. South Africa has also committed to joining the Just Energy Transition (JET) Partnership with France, Germany, the United Kingdom, the United States, and the EU. These partners are expected to speed up decarbonisation efforts of South Africa's economy with emphasis on decarbonising the electricity sector. Alongside, the funding should provide assistance to South Africa through collaboration on policy alignments. Policy alignment can help solve challenges such as finance and technical expertise which are slowing the energy transition. South Africa introduced carbon pricing to tax all greenhouse gas emissions. This policy fluctuated as enforcement was very weak. Furthermore, South Africa established its first Integrated Resource Plan (IRP) in 2010.

This plan has been amended four times. Created to move South Africa to a grid that runs on 41–77% renewable energy by 2030. However, there have been little to no movement towards this goal and plan. Rather, the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has been used as one of South Africa's methods of pulling in private investment. While the program has been largely successful, there have been setbacks due to regulatory delays, grid connectivity issues, and lack of government commitment to the program long term. The National Development Plan (NDP) was unveiled in 2012 to push for cleaner sources of energy. Therefore, South Africa had promised numerous sectors but followed through with little to no action.

South Africa has passed some of the world's strongest policy frameworks when looking at a just energy transition but has seen little impact from these policies. Policy uncertainty, lack of commitment, and slow-paced infrastructure have been a huge problem. Another issue that South Africa faces is related to the socio-economic makeup of South Africans. Transitioning to cleaner energy sources is important, but South Africa has an unemployment rate of over 40% and a Gini Coefficient of 0.63. The country has one of the highest rates of income social inequality in the world. Transitioning while taking into account social factors will allow for a "just transition", which could help mitigate some of the social imbalances that are seen today. Low-income households are most vulnerable to pollution, climate-induced extreme weather events, and lack of healthcare [29]. South Africa will have to ensure that they have a socially inclusive transition.

Due to these challenges mentioned above, governance is expected to play a large part in South Africa's renewable energy transition. Good governance will be able to allow for policy stability, clear regulatory ambits, and long-term commitment. If South



Africa's government cannot provide consistent and straightforward energy policies, the transition to renewable energy will be near impossible. Policy uncertainty, lack of commitment, and weak legislative support has plagued South Africa's transition up until this point.

The remainder of this paper is structured as follows. Section 2 contains the literature review; Section 3 describes the methodology; Section 4 discusses and interprets results; and Section 5 is conclusion and policy recommendations.

**Literature Review.** The mitigation of barriers towards renewable energy adoption is expected to have significant socio-economic and political consequences for South Africa. Although existing literature exploring governance-related studies in South Africa's energy transition is relatively novel, little research has been conducted to explore the moderating effects of governance on renewable energy uptake in South Africa, considering social imbalances (social inclusion) specifically. There is, however, existing evidence to suggest governance plays a significant role in facilitating successful renewable energy transitions overall. The significance of governance structures, energy policy uncertainty, and government effectiveness have been proven as reliable indicators of successful fossil fuel to renewable energy transitions in countries worldwide [12].

**Governance and Renewable Energy Transitions.** Regulatory constraints are often considered exogenous challenges to renewable energy deployment in most contemporary literature [11]; [25]. This stance neglects the fact that regulations are adaptable. Governance mechanisms function as coordination vehicles for transition efforts by aligning action amongst stakeholders. This entails institutional setups, policy tools, as well as stakeholder engagement tactics [12]. Institutional setup, in particular, should ensure policy alignment, regulatory stability, and synchronised actions amongst multiple stakeholders [24]. Scholars generally agree on governance but continue to contest the details of how governance should look like in South Africa, especially considering state-owned utilities and historical predisposition to coal.

Some authors [15] argue that renewable energy will only actualise the growth of a green economy when backed up by enabling policies from both governments and businesses. Carbon emissions management also plays a key role in the development of a green economy. Carbon emission management is defined as the intentional efforts taken to measure, moderate, and control carbon emissions [16]. Although CO<sub>2</sub> is the primary greenhouse gas responsible for the warming of our planet [9], the energy transition towards renewable energy is crucial in decarbonising efforts to maintain long-term sustainable growth [21]; [10]. The trajectory towards decarbonisation follows electrification through clean energy technology adoption, energy savings, and clean energy transitions. Certain technology such as Carbon Capture and Storage (CCS) are meant to help reduce emissions from coal power plants that cannot transition to renewable sources of energy [21]

Energy savings, also known as energy optimisation, intends to limit energy consumption per unit of product [10]. Transitioning to clean energy is said to be the

silver bullet for fossil fuel dependency [28]. On that note, policy and legislation play a crucial role in helping to control carbon emissions. Indonesia, for example, has pledged to reduce carbon emissions by 29% by 2030 as stated in their NDC. Carbon tax has also been legislated in some countries to help curb emissions, and others have opted to create carbon markets [21]

***Institutional Quality and Green Growth.*** From South Africa's energy transition perspective, Transition Management Theory (TMT) allows us to see how governance systems could better moderate between state-owned utility companies, government elites, industry players, and civil society towards enabling an accelerated just energy transition. Moreover, TMT focuses on adaptive governance and multi-level governance structures, which are well-suited to analyzing South Africa's divided political agenda among institutional players and a fragmented energy policy context with powerful coal supporters. By utilizing TMT for this study, the study aims to contribute to the literature on how South Africa could have better moderated governance structures between actors to allow for an energy transition without exacerbating social imbalances

Transition Management Theory assists in explaining how societies can anticipate and cope with complex transitions like the energy transition. Key characteristics of transition management include having long-term goals, flexibility, and involving stakeholders [18]; [12]. To that end, [1] provides empirical evidence on how institutional quality encourages investment in renewable energy. [6], discuss institutions as organisations, rules, and systems of economic interactions which can determine governance outcomes and public policy. [8], also highlighted that legal and institutional structures can enable or impede efficient renewable energy transition. The author empirically discovered that countries with better institutional quality tend to consume more renewable energy.

A handful of studies have also discussed how good governance can promote green growth through institutional quality. [22], found that increases in institutional quality pertaining to economic and political institutions have a direct positive effect on green growth. The authors found this to be through improvements in total factor carbon productivity. [20], provided implications within 46 BRI countries that it is important to improve institutional quality by reducing political as well as economic institutional risks to allow for green growth and innovation. Both studies highlight how good governance can enable green transition efforts by allowing for improvements to better governance and social welfare, especially those that promote technological advancements while limiting risk.

***South Africa's Energy Governance and Challenges.*** South Africa contextually struggles with their energy transition due to their long history of coal dependency. The government's relationship with coal stretches into state-owned utilities Eskom and previously state-owned Sasol. Eskom is South Africa's leading national generator of energy, owning 75% of coal-fired power plants that make up the 40 GW energy mix [5]. Sasol is a privately owned energy and chemicals company that specialises in coal-



to-liquid and chemical energy production. Coal mining played a major role in wealth redistribution to the government and the workforce since the end of apartheid in South Africa, further linking political elites with mining interests. However, Eskom's debts are mired in mismanagement crises with rising cost overruns and tariffs, and cannot keep up with energy demands. Eskom needs consistent bailouts from the state to service its unsustainable debt levels [4]. As a result, South Africa faces record-breaking load shedding because Eskom cannot generate enough electricity to supply the country's demand [29]. Although some mining companies like Glencore or Exxaro have begun imposing restrictions on further coal investment [3], policymakers continue to face substantial pressure from pro-coal factions. Coal-dependent stakeholders like trade unions, coal-linked industries and municipalities competing against global or local environmental pressures for RES uptake. The national policy debate is therefore strongly focused on job-losses and transition impacts on coal-dependent communities, like those in Mpumalanga Province, [23]; [26]. Anti-RES actors have also been bolstered by state rhetoric on 'clean coal'. Policy signals have broadly moved in favour of renewable energy uptake, but administrative regulations remain rigid and unpredictable. Investors have faced policy uncertainty as independent power producers (IPPs) contracts are not being honoured, and there has been a freeze on renewables procurement [7]. Supportive new actors continue to emerge around renewable energy uptake, such as progressive government elements, foreign independent power producers (IPPs), and civil society groups. Previous studies have delved into governance as a driver of renewable energy transition but have neglected its moderating role and effect on social inclusion in such a strong coal dependency nation like South Africa. This study seeks to bridge this knowledge gap by investigating how governance plays its role as a moderator of renewable energy transition in South Africa without a focus on social inclusion. Coal energy is highly predominant in South Africa due to various political, economic, and institutional factors that push back against renewable energy adoption. However, how governance plays a moderating role between these factors and renewable energy policies Vis-à-vis social inclusion has yet been understood. Therefore, this study investigates how governance affects renewable energy policy-making and effectiveness in South Africa with a balance for social inclusion. This study is novel because while other studies may have focused on stakeholder interactions, growth, or conflict, this study strictly discusses how South Africa's energy transition is moderated by governance systems and social policy gains. Additionally, research focusing on Africa's energy transition often discusses broad factors preventing the energy transition and does not get into specifics such as how certain government institutions or moderation may aid or push against social inclusion.

**Goals of the Article:** The study aims to investigate the moderating effect of governance on the relationship between renewable energy transition and social inclusion in South Africa. Thus, the study is guided by the following research

question: Does governance significantly moderate the renewable energy transition-social inclusion nexus in South Africa?

**Methods and Methodology.** Transition Management Theory (TMT) developed by [17] underpinned this study. TMT emphasizes the role of governance in managing long-term transitions and guiding societal change in a sustainable, inclusive way. Therefore, the theory helps to examine how governance influences the trajectory of South Africa's renewable energy transition and assesses the social impacts in terms of social outcomes. The first equation aims to model renewable energy adoption as a function of time when conditioned on governance and other factors. For example, we treat renewable energy adoption as a dynamic process where the share of renewable energy  $RE_t$  is influenced by  $Gov_{Etn_t}$  moderation. We can express this as a differential equation, where the rate of change of  $RE_t$  depends on  $Gov_{Etn_t}X_t$  and time:

$$\frac{dRE_t}{dt} = \beta_1 Gov_{Etn_t} + \beta_2 X_t - \beta_3 RE_t \quad (1)$$

where  $RE_t$  denotes renewable energy transition;

$Gov_{Etn_t}$  represents governance quality;

$X_t$  is a vector of other determinants of renewable energy transition (e.g., energy access, carbon emission, technological innovation, or investment);

$\beta_3 RE_t$  captures the adjustment process or diminishing marginal growth as renewable energy adoption matures.

Equation (1) states that the growth of renewable energy transition is positively influenced by governance quality and other enabling factors but gradually slows as renewable energy penetration increases.

Integrating Equation (1) over time yields the cumulative evolution of renewable energy transition:

$$RE_t = RE_{t_0} + \int_{t_0}^t (\beta_1 Gov_{Etn_t} + \beta_2 X_t - \beta_3 RE_t) dt \quad (2)$$

Equation (2) represents the cumulative path of renewable energy transition from the initial period  $t_0$  to time  $t$ . It shows that renewable energy adoption evolves continuously through governance support, complementary structural factors, and the system's adjustment dynamics.

With the evolution of the renewable energy transition, its effects on social inclusion can be expressed as;

$$\frac{dHDI_t}{dt} = \alpha_0 + \alpha_1 RE_t + \alpha_2 Gov_{Etn_t} - \alpha_3 HDI_{t-1} + \epsilon_t \quad (3)$$

where  $HDI_t$  represents social inclusion;

$\alpha_1$  measures the direct contribution of renewable energy transition;

$\alpha_2$  captures the contribution of governance to social inclusion;

$\alpha_3$  represents the persistence of social inclusion over time

Equation (3) describes how social inclusion evolves over time. Renewable energy transition contributes directly to improvements in social inclusion, while



governance strengthens these outcomes through effective institutions, policy implementation, and equitable distribution of transition benefits. The lagged social inclusion term reflects the dynamic persistence of human development.

Integrating Equation (3) gives the cumulative evolution of social inclusion:

$$dHDI_t = HDI_{t_0} + \int_{t_0}^t (\alpha_0 + \alpha_1 RE_t + \alpha_2 Gov_{Etn_t} + \alpha_3 HDI_{t-1}) dt \quad (4)$$

Equation (4) shows that social inclusion evolves cumulatively through the combined effects of renewable energy transition, governance quality, and previous levels of human development. Hence, the theoretical framework finally leads to the empirical model:

$$HDI_t = \alpha_0 + \alpha_1 RE_t + \alpha_2 Gov_{Etn_t} (RE_t * Gov_{Etn_t}) + \alpha_4 HDI_{t-1} + \epsilon_t \quad (5)$$

Equation (5) is the estimable model derived from Transition Management Theory. The interaction term  $(RE_t * Gov_{Etn_t})$  captures how governance influences the relationship between renewable energy transition and social inclusion. A positive coefficient indicates that stronger governance enhances the social benefits of renewable energy transition, whereas a negative coefficient suggests that weak governance constrains the realization of inclusive development outcomes.

The *ex-post-facto* analysis technique was used to determine whether governance moderation in South Africa's renewable energy transition has effects on social inclusion. This design employed considered events that happened in the past. Thus, the historical linkages between governance renewable energy transition outcomes especially on social inclusion data were used. Hence, the years 1990-2025 was considered for the examination. Data ranging from 1990-2025 enable the study to capture major events that occurred during governance transitions and how these affected the renewable energy transition in South Africa.

In South Africa, renewable energy transition programs started taking shape in 1990 after the new South African government took over, and there was a focus on creating policies to help deal with social inequalities which includes energy access. Policies between 1994 and 2008 helped set the foundation for renewable energy transition such as the White paper on energy. In 2008 to 2019, Renewable Energy Independent Power Producer Procurement Program (REIPPPP) led to an increased uptake of renewable energy; however, there were concerns if government considered social inclusion during energy transition. Between 2020 and 2025, improvement of policies such as the IRP 2019 with consideration for sustainable development and improved energy access to all. Therefore the scope of the study covers significant events needed to answer the research question.

Following descriptive statistics, the Vector Inflation Factor test among the variables were estimated to see how governance, renewable energy transition co-relates with the social outcomes (social inclusion). By doing this, the study ensure that the model does not violate the assumptions of covariance of conventional classical linear regression and problems of multicollinearity and spurious elasticities. The

stationarity test was also estimated using the Augmented Dickey Fuller test, and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test [13] and the Philip Perron (PP) test, helps to reconfirm the results found in the ADF test while accounting for any serial correlation in the residuals.

Determining if the variables are stationary at level or first difference helps in identifying the appropriate estimator to use. After establishing that all the variables were stationary at various levels, that is, there are some variables that are I (0) and other that are I (1); hence the ARDL approach is the most appropriate model for this study then the ARDL model was estimated for the long-run and short-run relationship between governance renewable energy transition and social inclusion, thus:

$$Y_t = \alpha_0 + \sum_{i=1}^{P_1} \beta_1 Y_{t-i} + \sum_{j=1}^{q_i} \gamma_j X_{t-j} + \sum_{k=1}^{\gamma_j} \delta_k \Delta Gov_{Etn_t} + \epsilon_t \quad (6)$$

$Y_t$  = Social inclusion index (such as income, healthcare, education) for year t.

$X_t$  = other variables affecting renewable energy transition at year t.

$Gov_{Etn_t}$  = Governance index variables (government effectiveness policy) for year t.

$\alpha$  = Intercept.

$\beta_i, \gamma_j, \delta_k$  = Coefficients to be estimated.

$p, q, r$  = Number of lag years for the dependent, independent and governance variable respectively.

$\epsilon_t$  = Error term.

The Bound test determines if there exist long-run dynamics between variables contained in the ARDL model. This test also determines if the variables are co-integrated. If they are co-integrated, then we can conclude that there exists a significant long-run equilibrium relationship among governance, renewable energy transition, and social inclusion. Once variables are co-integrated, the study can then estimate long-run coefficients and determine the effect governance has on renewable energy transition's impact on social inclusion. Hence, the Error Correction Model (ECM) is obtained from the ARDL to analyse short-run dynamics.

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{P_1} \beta_1 \Delta Y_{t-i} + \sum_{j=1}^{q_i} \gamma_j \Delta X_{t-j} + \sum_{k=1}^{\gamma_j} \delta_k \Delta Gov_{Etn_t} + \lambda \cdot EC_{t-1} + \epsilon_t \quad (7)$$

Where:

$Y_t$  denotes the dependent variable

$\Delta$  denotes the difference operator.

$EC_{t-1}$  is the error correction term representing the deviation from long-run equilibrium in the previous period.

$\lambda$  is the coefficient of the error correction term, which indicates the speed at which the system returns to equilibrium after a shock.

Furthermore, to ensure the robustness of the results, the study perform several checks such as model specification tests, serial correlation in the residuals,



heteroskedasticity, and the normality of the error terms to ensure the reliability of the ARDL estimates. Therefore, the empirical model is specified as follows:

$$HDI_t = \alpha_0 + \alpha_1 RE_t + \alpha_2 Gov_t + \alpha_3 (RE_t * Gov_{Etn_t}) + \alpha_4 HDI_{t-1} + \beta_5 CO_2 + Coint_{Eq-1} + \epsilon_t \quad (8)$$

**Table 1.**

| <b>Measurement and Variables Sources</b> |                                                                                                                                                                                                                                                                                                                                                                          |                         |
|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Variable</b>                          | <b>Measurement of Variable</b>                                                                                                                                                                                                                                                                                                                                           | <b>Source(s)</b>        |
| Social inclusion (HDI)                   | The Human Development Index (HDI) is a measure of human development that measures different social factors, such as health, education, and income                                                                                                                                                                                                                        | Our World in Data, 2025 |
| Governance $Gov_{Etn}$                   | The indices of Governance $Gov_{Etn}$ measure how well are the government policies in South Africa                                                                                                                                                                                                                                                                       | Our World in Data, 2025 |
| Renewable Energy Transition (RE)         | The percentage of renewable energy in total energy consumption is used to measure the renewable energy transition. It directly measures the shift from conventional energy sources (such as fossil fuels) to renewable sources (such as solar, wind, hydro, and so on). By capturing the proportion or absolute amount of energy that is consumed from renewable sources | Our World in Data, 2025 |
| Carbon Emission (CO <sub>2</sub> )       | Carbon emissions (CO <sub>2</sub> ) is measured by per capita CO <sub>2</sub> emitted in South Africa, indicating the environmental impact of the used energy and the transition process from fossil fuels                                                                                                                                                               | Our World in Data, 2025 |

Source: Author's compilations, 2026.

Social inclusion is proxied by the Human Development Index (HDI), which captures key dimensions of human well-being, including health, education, and income. Although HDI is primarily recognized as a measure of human development rather than a direct measure of social inclusion, it is widely used in the literature to reflect the extent to which individuals benefit from socioeconomic progress through improved capabilities and living standards. In the context of South Africa's renewable energy transition, changes in HDI provide a useful indication of whether the socioeconomic benefits associated with the transition are broadly shared across the population. Renewable energy policies and increased clean energy adoption can enhance social inclusion by improving access to affordable and reliable electricity, creating employment opportunities, and supporting better health and educational outcomes. Conversely, the transition may adversely affect communities that depend heavily on fossil fuel industries, particularly coal mining, through job losses and income disruptions if appropriate governance and just transition policies are absent. Consequently, HDI is employed as a comprehensive proxy for social inclusion because it reflects changes in the welfare dimensions most likely to be influenced by the renewable energy transition and governance interventions.

Government effectiveness is linked to the energy transition as it represents the government's ability to create policies, institutions, and legislation that facilitate or

restrain the transition to renewable energy. The government effectiveness captures how policies are carried out within the state context. Furthermore, renewable Energy transition requires robust regulatory environments and policy frameworks that enable clean energy investments. Moreover, government capability to execute rules and policies is likely to ensure equality among various groups during this transition period.

Hence, these indicator have been selected because it measures state capacity, which is vital for the study, and aimed at establishing whether governance moderate the effect of energy transition on social inclusion. Government efforts could also have direct impact on the swiftness of the energy transition in South Africa as well as social equality. Weak governance could result in policies that fail to consider certain social groups within the country. This directly relates to the energy sector by leaving some groups behind with regard to energy access as well as energy consumption.

**Research Results and Discussion.** Both the environmental quality component of governance and the social inclusion dimension influence renewable Energy Transition. Modern Renewable Energy Consumption is used as a proxy variable to measure how South Africa has transitioned from non-renewable to renewable energy sources. Government policies are able to either slow down or fast track this transition. Furthermore, the type of policies passed within a government can influence how inclusive this transition is. This variable measures the outcome of the energy transition. The clean energy transition might help South Africa address some of the social inequalities, and might impoverish citizens who are tied to coal mining as their major or only source of income. An increase in clean energy consumption might suggest the South African government provides energy to all its citizens. While a shift to renewable energy might leave some social groups behind, it also has the capability of improving social equality by providing clean and cheap energy. Carbon emissions (CO<sub>2</sub>) are included as an extraneous variable in the model. Though they could play an important role in determining the environmental impact, it measures the per capita CO<sub>2</sub> emitted in South Africa, suggesting the environmental health of the used energy and the transition process from fossil fuels.

Table 2 shows the descriptive statistics of the study variables. The mean values of HDI, RE,  $Gov_{Ent}$  and CO<sub>2</sub> are 0.671, 1.429, 0.441 and 8.040 correspondingly with moderate variability across the sample. All of the variables are slightly positively skewed. The kurtosis values indicate that the distributions are mostly platykurtic. Also, the Jarque-Bera test results are statistically insignificant ( $p > 0.05$ ) showing that the variables are generally normally distributed and suitable for further economic analysis.

**Table 2.**

| Descriptive Statistics |          |          |             |                 |
|------------------------|----------|----------|-------------|-----------------|
|                        | HDI      | RE       | $Gov_{Ent}$ | CO <sub>2</sub> |
| Mean                   | 0.671200 | 1.428627 | 0.440828    | 8.039837        |
| Median                 | 0.654000 | 1.201260 | 0.332500    | 8.022166        |
| Maximum                | 0.742000 | 3.100000 | 1.000000    | 9.677716        |
| Minimum                | 0.610000 | 0.146000 | -0.226000   | 6.871580        |
| Std. Dev.              | 0.046570 | 0.738790 | 0.371949    | 0.739032        |
| Skewness               | 0.243287 | 0.781633 | 0.356128    | 0.213898        |

|              | HDI      | RE       | $Gov_{Ent}$ | CO2      |
|--------------|----------|----------|-------------|----------|
| Kurtosis     | 1.465664 | 2.944867 | 2.136571    | 2.309056 |
| Jarque-Bera  | 3.886413 | 3.670258 | 1.879228    | 0.990619 |
| Probability  | 0.143244 | 0.159593 | 0.390779    | 0.609382 |
| Sum          | 24.16320 | 51.43058 | 15.86980    | 289.4341 |
| Sum Sq. Dev. | 0.075906 | 19.10340 | 4.842107    | 19.11590 |
| Observations | 36       | 36       | 36          | 36       |

\*Source: Author's computation, 2026

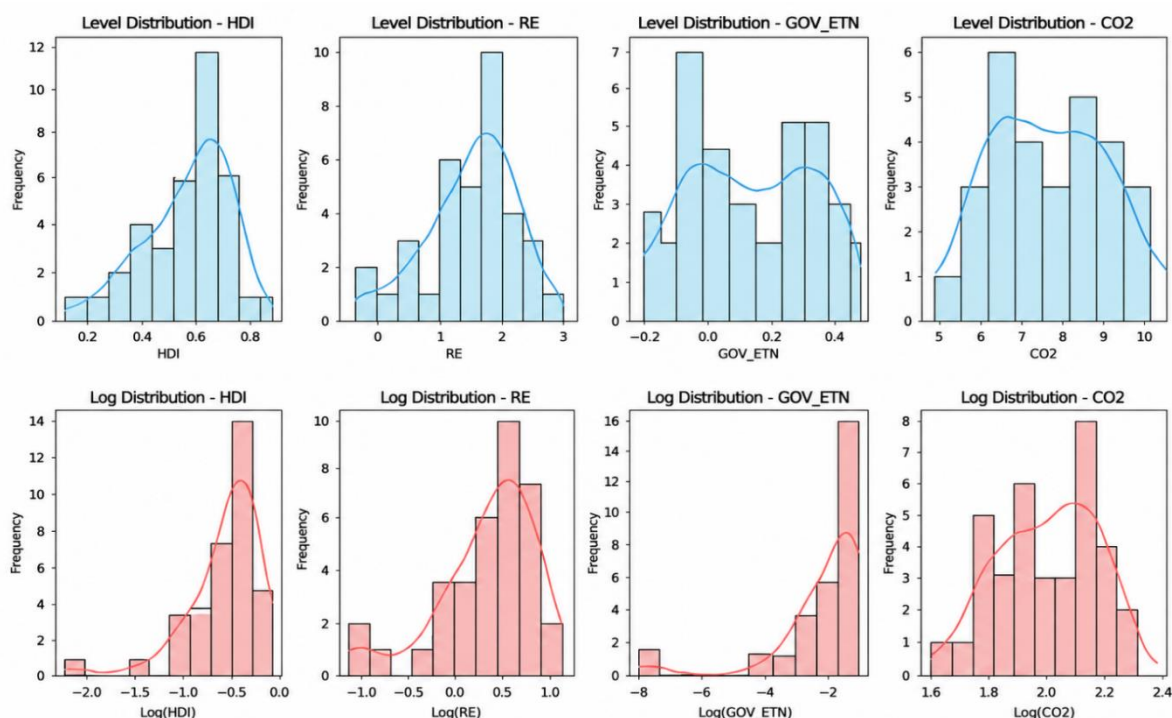


**Fig 1. Comparison of Level and Log-Transformed Distributions**

\*Source: Author's computation, 2026

This graph is necessary to show the spread of the data as well as characteristics of the dataset in its original form and transformation form. It enhances our knowledge of the statistics of our data, such as skewness, outliers. The transformation also helps to decide the suitability of the data for further analysis. Hence, the outcomes show the appropriateness of the dataset for further estimation.

**Table 3.**

| VIF Multicollinearity Test |                      |                |              |
|----------------------------|----------------------|----------------|--------------|
| Variable                   | Coefficient Variance | Uncentered VIF | Centered VIF |
| $HDI$                      | 1.95E-06             | 3.401252       | 1.689423     |
| $RE$                       | 52.13127             | 3.287105       | 2.145362     |
| $Gov_{Ent}$                | 10.74312             | 4.420846       | 2.656138     |
| $CO2$                      | 7.453001             | 3.924415       | 2.017864     |

\*Source: Author's computation 2026

The Variance Inflation Factor (VIF) values in Table 3 demonstrate that the model do not have the problems of multicollinearity. The Uncentered VIF and Centered VIF values are both less than 5, which means that each variable is not too dependent on the others. This makes sure that the regression estimations are accurate and that multicollinearity does not cause inflation in the estimation.

**Table 4.**

| Variable           | Unit Root Test Results<br>@Level |                                  |                                  | @First Difference                |                               |                                  | Order of Int |
|--------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|-------------------------------|----------------------------------|--------------|
|                    | ADF                              | PP                               | KPSS                             | ADF                              | PP                            | KPSS                             |              |
|                    | Intercept<br>(Trend & Intercept) | Intercept<br>(Trend & Intercept) | Intercept<br>(Trend & Intercept) | Intercept<br>(Trend & Intercept) | Intercept (Trend & Intercept) | Intercept<br>(Trend & Intercept) |              |
| HDI                | 0.489                            | 0.542                            | 0.345                            | -1.232*                          | -1.171*                       | 0.411**                          | I(1)         |
| RE                 | 0.312                            | 0.593                            | 0.285                            | -2.456*                          | -1.523*                       | 0.345**                          | I(1)         |
| Gov <sub>Etn</sub> | 0.582                            | 0.578                            | 0.592                            | -1.671*                          | -1.453*                       | 0.665**                          | I(1)         |
| CO2                | 0.289                            | 0.521                            | 0.302                            | -1.995*                          | -1.876*                       | 0.375**                          | I(1)         |

\*Source: Author's computation 2026

Note. \*P<0.01, \*\*P<0.05

Table 4 shows the results of ADF, PP and KPSS unit root tests. HDI, RE, Gov<sub>Etn</sub> and CO2 are I(1). Hence, ARDL bounds testing approach can be adopted.

Fig. 2 illustrates four trends. Social inclusion explains how fair access to energy sources is and has been trending upward, but later began a steadily decline. Renewable energy transition process shows the change in the process over time and has been fluctuating which indicates that government efforts to moderate this transition have not been consistent but they have been improving at points. Government effectiveness explains government performance during this transition process. While this has been improving moderately, there is still room for growth to ensure the process is as fair and inclusive as possible. Carbon emissions have been declining which indicates that the renewable energy transition has been relatively helpful in decreasing the amount of emitted carbon which does not only help the environment but those in vulnerable communities.

The interactive chart in Fig 3 shows the overall social inclusion trend from 1990 to 2025. The metric is an indication of how much the country has improved in social inclusion and reducing social outcomes in its process of moderating the energy transition process. However, it took a sudden decline in both 2024 and 2025 which could be an indication of policy effect. Renewable energy transition process fluctuates throughout the graph. There are high increments that can be seen throughout the early 2000 and subsequent years. This is an indication of how government and market action towards renewable energy transition changes in intensity. Government effectiveness in the moderation process of renewable energy transition process is mostly flat throughout the years. This indicates that even though social equity slightly improved late 2024, governance needs to step up their effort to maintain improvement. Carbon

emission sharply decreases after 2023 which can be attributed to policy influence during the period to enhance renewable energies. However, it quickly dropped in 2024 and 2025 which is not unconnected to policy effect as well.

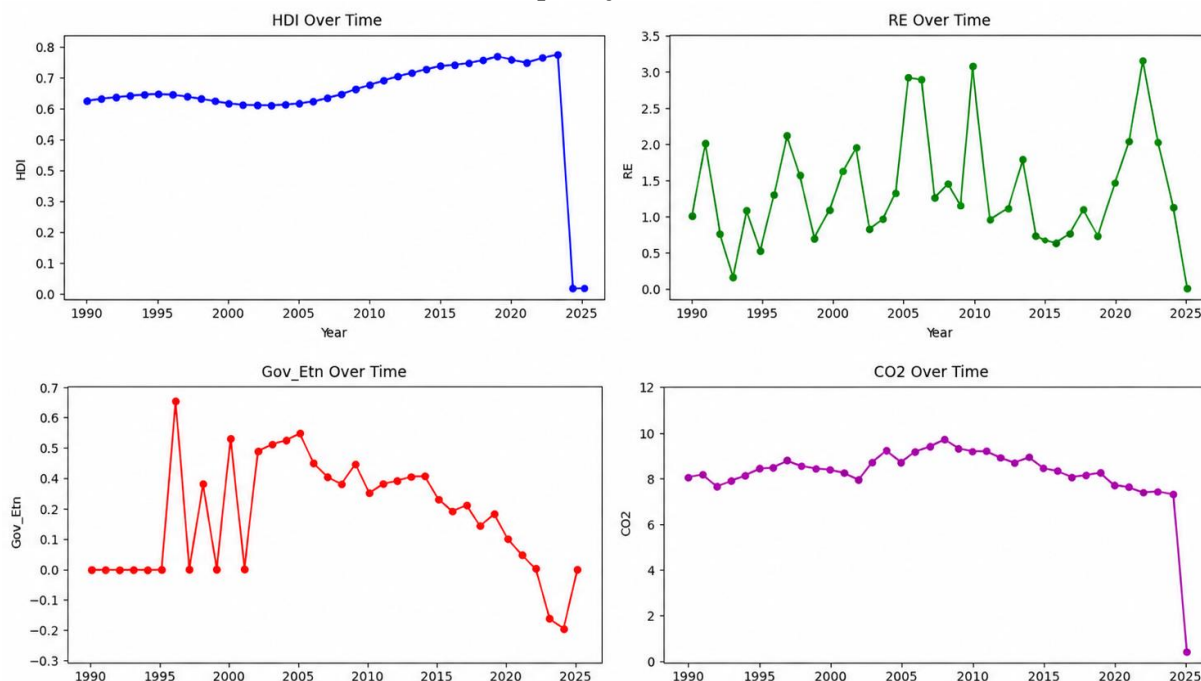


**Fig. 2 Trends of key variables over time (1990-2025)**

*\*Source: Author's computation, 2026*

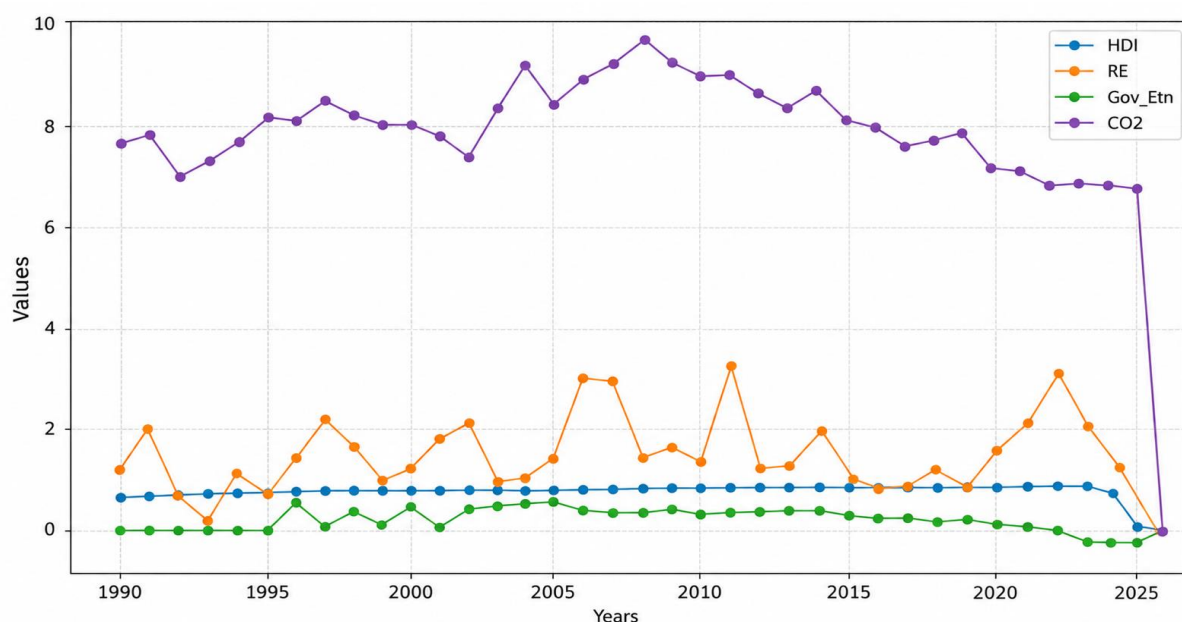


**Fig. 3 Interactive Trends in South Africa's Renewable Energy Transition, Governance, and Social Outcomes (1990-2025)**

*\*Source: Author's computation, 2026*

Table 5.

**Optimal Lag Length Selection Criteria**

| Lag Length | LogL     | LR       | FPE       | AIC     | SC     | HQ      |
|------------|----------|----------|-----------|---------|--------|---------|
| 0          | -130.000 | NA       | 0.075     | 8.200   | 8.470  | 8.290   |
| 1          | 70.000   | 320.000* | 9.50e-09* | -1.300* | 0.580* | -0.800* |

Source: Author's computation, 2026

Table 5 shows the values for different lag lengths and highlights that Lag 1 is optimal based on the criteria (LogL, LR, FPE, AIC, SC, HQ).

Table 6.

**Bound Test Result**

| Statistic   | 1% Lower Bound | 1% Upper Bound | 5% Lower Bound | 5% Upper Bound | 10% Lower Bound | 10% Upper Bound |
|-------------|----------------|----------------|----------------|----------------|-----------------|-----------------|
| F-Statistic | 5.2574         | 2.75           | 4.00           | 2.50           | 3.20            | 2.90            |

\*Source: Author's computation, 2026

Bound testing procedure in Table 6 has been applied in this study to show the existence of long-run relationship between the variables. [19] showed that bound testing approach to cointegration is based on F-test. F-statistic tests the null hypothesis of no cointegration between the variables, that is, absence of long-run relationship against the alternative hypothesis of cointegration. Thus;

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0.$$

This implies **no long-run (cointegrating) relationship** among the variables.

$$H_1: \text{At least one } \beta_i \neq 0, i = 1, 2 \dots 5$$

This implies **a long-run (cointegrating) relationship exists** among the variables.

Table 7.

**Long Run Results**

Dependent variable HDI

| Variable                | Coefficient | Std. Error | t-Statistic | Prob.         |
|-------------------------|-------------|------------|-------------|---------------|
| HDI(-1)                 | 1.622       | 0.302      | 5.371       | <b>0.000*</b> |
| RE                      | -0.586      | 0.236      | -2.488      | 0.018**       |
| Gov <sub>Etn</sub> * RE | -0.433      | 0.209      | -2.075      | 0.040**       |
| CO2                     | 0.122       | 0.136      | 0.899       | 0.370         |

\*Source: Author's computation 2026

\*P < 0.01, \*\*P < 0.05

The long-run results obtained in Table 7 identify some of the features of renewable energy transition and how they affects social inclusion in South Africa. The citizen of South Africa's transit from coal and towards renewables has many social implications for those who depend on the coal industry. The coefficient for renewable energy transition is negative and statistically significant at (-0.586) shows that there is a negative impact of renewable energy transition in South Africa in the long-run.



Transitioning to renewable energy sources informed displacement of workers and communities that depend on coal mines for their livelihood. This displacement and loss of livelihood in coal translates to social exclusion and lack of access to basic services that promote equality thus decreasing social inclusion in the long run. The renewable energy transition can affect social inclusion and by directly causing job losses, economic marginalisation, and poverty for those that were dependent on coal mine livelihoods.

Coal mining is deeply rooted in the South African economy. Those who are tied to coal economically will have a difficult time recalibrating their livelihoods to something else without proper support. If this transition occurs without the proper policies that focus on job transition programs, social grants, and poverty relief, it could cause greater social segregation between rural and urban or industrialised communities. This finding is in tandem with the studies of [22] and [20] who found that good governance can enable green transition efforts by allowing for improvements to better governance and social welfare, especially those that support industrial improvements while limiting risk of displacement. The coefficient for government moderation in renewable energy transition process is negative and significant at (-0.433). This suggests that too much government focus on ethnic reconciliation during renewable energy transition can cause greater gaps in social inclusion. Policies that focus only on specific groups of people during the transition can cause certain coal-dependent communities to be left behind.

Carbon Emissions is insignificant (0.370) showing that Carbon Emissions is not impactful in affecting social inclusion in the long-run. There is a weak relationship between carbon emissions and social inclusion in South Africa. Transitioning to renewable energies may help lower carbon emissions. However, there is no significant direct relationship between carbon emissions and social inclusion. Carbon emissions do not directly affect social access to education, health services and can be reduced by transitioning to renewable energies. However, this does not have long run effects on improving social inclusion.

**Table 8.**

| Short Run Results                           |             |             |             |         |
|---------------------------------------------|-------------|-------------|-------------|---------|
| Variable                                    | Coefficient | Std. Error  | t-Statistic | Prob.*  |
| $\Delta\text{HDI}(-1)$                      | 1.187       | 0.253       | 4.6951      | 0.000*  |
| $\Delta\text{RE}$                           | 0.205       | 0.113       | 1.809       | 0.081   |
| $\Delta\text{Gov}_{\text{Etn}}^* \text{RE}$ | -0.082      | 0.032       | -2.545      | 0.018** |
| $\Delta\text{CO}_2$                         | 0.082       | 0.006       | 12.736      | 0.000*  |
| $\text{CointEq}(-1)^*$                      | -0.426      | 0.168       | -2.538      | 0.017** |
| R-squared                                   | 0.877       |             |             |         |
| Adjusted R-squared                          | 0.855       |             |             |         |
| F-statistic                                 | 39.877      | Durbin-     |             | 1.524   |
| Prob                                        | (0.000*)    | Watson stat |             |         |

\*Source: Author's computation 2026

\* $P < 0.01$ , \*\* $P < 0.05$

The short run results in Table 8, shows a lagged dependent variable of a period behind, meaning that the results being displayed are only considering the transitional effects of renewables expansion on social inclusion. This means that policies have begun to be enacted, structures are beginning to change, but their effects have not lasted long enough to be considered long term. The positive and significant relationship between lagged effects of social inclusion (1.187) suggests that South Africa's improvements in social development in prior years (access to healthcare, education, infrastructure, and so on.) are having lasting effects. South Africa has continued to increase human development as the transition away from coal continues. This signifies that South Africa government needs to keep policies and projects focused on improving human capital and increasing public welfare, this findings is in tandem with the study of [1] who found that institutional quality encourages renewable energy transitioning. The positive coefficient for renewable energy transition (0.081) is marginally significant. Renewable energy expansion has begun to aid social inclusion but has not work to its fullest potential. It could also be capturing benefits from energy efficiency, healthcare improvements from transitioning away from coal-powered energy, or other sectors not mentioned.

This effect will become more certain as more time passes and the renewable energy sector expands to meet its objectives. However, if this coefficient were to turn negative, it could be an indication that the objectives of increasing social inclusion or decreasing social inclusion are not being met despite the renewable energy transition. This coefficient suggests that policies and developments geared towards specific ethnic groups are not reaching coal-dependent workers and hurting social equity. South Africa has made past improvements to social development that will continue to have positive effects, but they must not become complacent. The transition away from coal will require continuous investments in public services and human capital.

**Table 9.**

| <b>Heteroskedasticity Test: Breusch-Pagan-Godfrey</b> |        |                     |       |
|-------------------------------------------------------|--------|---------------------|-------|
| F-statistic                                           | 2.418  | Prob. F(5,28)       | 0.061 |
| Obs*R-squared                                         | 10.253 | Prob. Chi-Square(5) | 0.068 |
| Scaled explained SS                                   | 9.741  | Prob. Chi-Square(5) | 0.083 |

*\*Source: Author's computation 2026*

The three test statistics in Table 9 indicate that there is no significant evidence of heteroskedasticity at the 5% level. Since all three p-values of the test are greater than 0.05. Thus, heteroskedasticity does not exist in the estimation.

**Table 10.**

| <b>Breusch-Godfrey Serial Correlation LM Test</b> |       |                     |       |
|---------------------------------------------------|-------|---------------------|-------|
| F-statistic                                       | 1.281 | Prob. F(1,27)       | 0.268 |
| Obs*R-squared                                     | 1.540 | Prob. Chi-Square(1) | 0.215 |

*\*Source: Author's computation 2026*

Based on the F-statistic and the Obs\*R-squared test results in Table 10, the null hypothesis of no serial correlation at the 5% significance level is not rejected. So,



based on this test result, it can be concluded that there is no strong proof of serial correlation in the model.

**Conclusion and Prospects for Further Research.** The paper examines the moderating function of the South African government in the renewable energy transition and its effects on social inclusion. The long-run result shows that the move from fossil fuel energy consumption to renewable energy negatively affects social inclusion, particularly due to the displacement of coal-dependent workers and communities. The transition process unfavorably affected coal dependent set of people. Government intervention is weak, with few or no inclusive policies to cushion social outcomes during the study period. This would increase the rural-urban divide if coal-dependent communities, for example, are left behind. There is no significant relationship between carbon emissions and social inclusion in the long run, which suggests that reducing emissions does not allow for social equality.

Furthermore, in the short run, government moderation in the transition process improves social inclusion. Improvements in social factors such as healthcare and education access allow citizens to have better lives. However, while renewable energy transitions have had early signs of social benefits, they have not significantly contributed to social inclusion in the short-run. Government improvement of human capital is needed to show progress from the energy transition. Social welfare should still be prioritised when transitioning to cleaner energy. Therefore, policymakers should prioritise transition policies that can ensure that the renewable energy transition does not leave communities and individuals behind. Transition policies like job retraining programs for coal workers will help coal-dependent communities find jobs within the renewable energy sector and other sectors. Investment towards regions that previously relied on coal mining can help diversify communities' employment options.

More human capital should be invested into allowing citizens to better their lives, especially in rural areas that depend on coal mining. Ensure that government services are provided to everyone and not only certain ethnic groups. Policies should be implemented to provide wealth redistribution. Since the study showed that improving access to education and healthcare services improves social outcomes. Hence, this study contributes to the literature by focusing on how governance moderation in the energy renewable transition process can affect social inclusion. Most literature regarding energy transitions focus on either the economic or environmental impacts of the transition, but not how it affects other factors of development. This study shows that although there can be short-run benefits to transitioning, intervention from the government is necessary to allow everyone benefit of the renewable energy transitioning in South Africa. However, this study is limited in exploring other governance compositions, such as political instability and corruption. Future research can explore this interaction on transitioning outcomes. More so, comparative studies with other countries encountering similar challenges would offer more insights for formulating equitable renewable energy transition policy.

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**AI Use Declaration.** The author declare that no artificial intelligence (AI) tools were used in the design of the study, data collection, data analysis, interpretation of results, or the development of the research findings. The author takes full responsibility for the content, accuracy, and integrity of the manuscript.

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