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The Welfare Impacts of Renewable Energy Sources in South Africa

A Research Report submitted in partial fulfilment of the Degree of Master of Commerce (Applied Development Economics)
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The Welfare Impacts of Renewable Energy Sources in South Africa

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Abstract

This paper examines the welfare impacts of renewable energy sources in South Africa. It does so by examining the potential implications for Eskom's future in the electricity market by analysing a sample time series data from 1999 to 2019 and performing a structural Vector Autoregression (SVAR) as well as impulse response functions to investigate the interactions. The results suggest that non-renewable energy consumption has a greater positive impact on electricity access in South Africa while renewable energy consumption has a small positive effect on the welfare of South Africans. However, the results indicate that, in the presence of corruption, non-renewable energy consumption has a positive impact on the welfare of South Africans while renewable energy consumption potentially reduces the welfare of South Africans. Moreover, the results from the analysis suggest that renewable energy projects conducted by the government are likely to be vulnerable to corruption and are likely to have a negative influence on the access to electricity and thus the welfare of South Africans. As a result, it is critical that South Africa promotes greater government coordination, by creating an enabling environment for independent power producers to participate in the electricity market and embrace the transition while keeping the negative effects on energy poverty in mind. Consequently, the environment for sustainable development is likely to arise.

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1 Introduction

The inconsistency in energy supply by South Africa's vertically integrated energy provider, Eskom, has raised many questions relating to the link between development and the country's ability to manage State Owned Enterprises (SOEs). Since 2007, Eskom has not been able to guarantee a stable supply of electricity. Some of the issues that were found by ratings agencies, such as Fitch, and Moody's, were that Eskom had massive problems that arose from project management (Eskom founding Affidavit, 2018). These can be broken down into three major areas. Projects may be approved however, they tend to lose economic value as the project progresses, agency costs that arise from monitoring projects, as well as organisational framework, corporate governance, and political control. South Africa's electricity system serves as a representation of a path-dependent socio-technical system with strong entrenched interests in preserving the current state of affairs. A socio-technical regime is a dominant method of carrying out any societal function, such as the production and consumption of electricity (Ting & Byrne, 2020). In addition, when politics becomes entwined with a technological change, the change is referred to as technopolitical. Given the vertical integration of Eskom, renewable energy developers contend not only with the challenges of relatively new technologies, but also with strong governing interests seeking to keep the regime in place. Factors such as framing forces of doctrines, institutions, discourses, and political and economic trends play a significant role in this socio-technical system. This is motivated by considerations of the role of incumbent actors in fossil-fuel energy systems, whose systemic hegemony in energy investment and policy shapes the spaces available for alternative development.

Given the proposed shift to renewable energy solutions to address the current energy crisis, this study examines the welfare impacts of renewable energy sources in South Africa. Prior research shows how the instabilities of electricity supply has led to a crisis (Phalatse, 2020). Further linkages may be conceptualized to show its impact on the levels of development seen over the years in South Africa. South Africa as a country faces challenges that are beyond just the provision of services. The introduction of independent power providers and renewable energy into the electricity market have been identified as proposed solutions to the problem. This study aims to analyse the impact that the introduction of independent power providers (IPPs) could have for the energy efficiency in the country as well as the welfare within society. This study also aims to evaluate how the proposed solutions impact energy poverty and inequality in South Africa. Bouzarovski and Petrova (2015) argue that the literature available

in developing countries focuses on binary indicators of household access to electricity, which do not accurately measure energy poverty. Energy inefficiency is a major contributor to energy poverty (Policy Department A: Economic and Scientific Policy, 2020). Our generation faces a dual challenge: the majority of South Africans continue to live in poverty, and so we must remain focused in combating energy poverty. However, success in this fight will only translate into better living conditions for today's youth if we can simultaneously reduce greenhouse gas emissions.

Considering the recent discussion by the government to amend the Electricity Regulation Act (Act 4 of 2006 as amended) to open the market to private suppliers, the question to be posed is whether Eskom can realize the desires for social development within a competitive framework. Currently, the act provides for the enactment of regulations to ensure that incentives and penalties are legislated in order to carry out the Power Conservation Programme.

The challenges faced are rooted from the Political-Economic linkages that are found within the process of policy implementation and project management. McCauley and Todd (2021) identify a lack of literature on barriers and develop a new classification system of policy barriers. It is beneficial to generate ideas about the policy effects of the research and existing findings for actions that the South African government should take. Thus, there is a need to assess the policy and political environment in order to provide further intuition into the discussion. This report will be separated into three parts. Firstly, a brief overview of the literature that relates to the theories around development, as well as a review of literature related to the topic in question. Secondly, an outline of the econometric analysis as well as the empirical results. And lastly, an analysis of the political economy of South Africa's economy and the electricity industry as well as a discussion of the policy implications of renewable energy and independent power providers policy (IPP's).

1.1 Research questions

Given that renewable energy offer diversification to the energy market, the question of affordability for low-income households arises. In view of proposed solutions such as transitioning into renewable energy and private supply of electricity, the paper examines the potential implications for Eskom's future in the electricity market. What is the role and impact of governance on the access to electricity? What is the impact of renewable energy investments on welfare (energy poverty)?

2 Literature Review

This section provides a review of other research and academic work that discusses topics related to the study. In the literature there is a vast amount of research that examines the sustainability of energy supply and energy poverty. There is also a vast amount of literature that discusses the political economy of the electricity market in South Africa. An example of this is the study conducted by Stavrou (1992) which explores the nature of the governance of the market in the 1980s in comparison to the 1990s. Both Stavrou (1992) and Gateway (2012) explain the different institutions that affected the ability for Eskom's supply to match the country's developmental needs. A specific focus of the research was to highlight policies that the African Nation Congress (ANC) applied to shape development, and they thus identified that political and economic policy are driving factors in the nature of supply and cost of electricity in South Africa (Stavrou, 1992). Steyn (2016) discusses the uncertainty of electricity by researching the linkages between the financialization of Eskom through investments in the power sector and the management strategies. The findings of the paper attribute the problems to historical cost accounting and inefficiencies in the project management (Steyn, 2016). Further literature assesses the outlook of the supply of energy based on Renewable Energy projects that were planned to be implemented over 30 years. This literature indicates that the commencement of these projects was meant to help with increasing the energy supply. However, this research paper does not have real discussions on the economic effect of the results obtained from the study (Giglmayr, Brent, Gauche, & Fechner, 2015).

Mondi (2018) also explores the competitive nature of the electricity market and whether the state-run monopoly, Eskom, has the best suited framework to manage the generation needs of the country. The author explains that a restructuring of the electricity market is a necessary step to development (Mondi, 2018). Research by Lloyd (2017) and Nkomo (2005) similarly discusses the role of energy in development. They draw linkages on the energy sector and the social as well as economic circumstances within South Africa. However, Nkomo's (2005) findings show that he faced challenges while assessing the problem due to limitation of data and Lloyd (2017) fails to demonstrate a clearer specification for the framework and discussion that is presented. Evidence by Sardokie and Adams' (2020) study on the relationship between electricity access and income inequality suggests that although affordability of modern energy services is a critical barrier to scaling solutions that improve access to electricity, corruption appears to hinder any chances of achieving sustainable energy goals. The long-term

consequences of governance and political stability on sustainable economic growth and development possibly pose a bigger threat than inequality.

A more intricately linked research paper titled the significance of electricity supply to industrial growth in South Africa provides a quantitative analysis of the relationship between energy supply and industrial growth (Ateba, Prinsloo, & Gawlik, 2019). They conducted the study by collecting descriptive and bivariate data from enterprises across the services, manufacturing, and mining industries to establish a causal relationship of interest. They found that a direct relationship between the two variables was established. Thus, decreasing electricity sustainability leads to South Africa's industrial decline and so declining economic growth. Their conclusion is that public sector should apply an improvement in their governance framework to ensure policies that will prioritize electricity sustainability to industries (Ateba, Prinsloo, & Gawlik, 2019). Though the researchers propose that the research design was quantitative, and results were presented, there was no empirical specification or model provided which explained their methodological framework. More recent research by Xu, et al (2022) propose a corrected alternative to this study by constructing a panel study using fixed effects (FE) and generalized method of moments (GMM) econometric methods to conduct an analysis of the impact of energy crises on the profitability and productivity of businesses in Pakistan. Much like the previous article, this study confirmed that energy supply is highly critical to business profitability and productivity (Xu, et al., 2022). However, the researchers identify that the endogeneity of the electricity shortfall at the firm and district levels on firm productivity may lead to an underestimation of the impact of electricity shortfall which reduces the effect of the causal relationship of interest. Despite this, one can use this to draw comparisons to the South African energy crisis, as the context of the paper provides an analysis based on an emerging economy perspective.

A further review of literature for South Africa indicates that Monyei and Adewumi (2017) as well as Ye and Koch (2021) have been able to comprehensively indicate a measure that illustrate a growing energy poverty in South Africa. StatsSA (2017) also illustrate an estimated 5.5 percent increase in South African poverty rates. Since increasing electricity tariffs cause households to spend more of their disposable income on purchasing fewer electricity units, it can be deduced that increasing poverty will directly result in decreasing disposable income and increasing energy poverty.

Phalatse (2020) provides an overview on the crisis facing the South African electricity provider, Eskom. In this paper, she identifies the various aspects of Eskom's crisis as roots of the problem and evaluates proposed reforms that could be solutions to improve the sustainability of the electricity supply. The paper reiterates finding from the affidavit mentioned earlier in this article. Although Phalatse (2020) also links Eskom's declining profitability to the financial management of projects, the accumulation of debt, huge mismatch in projected costs of constructing generating units in Medupi and Kusile power stations in comparison to the actual cost of construction, and the change in coal prices, The paper is a working paper that focuses more on providing theoretical economic evidence with very little empirical evidence to support the discussion. She adds that Eskom's problems are exacerbated by the growing misuse of economic transformation goals and developmental agenda for corruption and private gain. Like several articles on the topic, she proposes the restructuring of Eskom, debt alleviation strategies such international funding and redirecting government funds, transitioning into renewable energy, and the introduction of independent power providers (IPP's) as solutions to this crisis.

The complicated nature of the electricity supply system in South Africa indicates that implementation of the proposed solutions is not quite simple. Exploring more financial and econometric implications would support the proposed policy actions. In contrast to previous research focused on the importance of a sustainable electricity supply for economic development and explaining why renewable solutions can meet the sustainable needs of the South African economy, this research adds to the existing literature by providing econometric evidence of the difference in welfare that may result from the proposed remedy to the energy crisis along with evidence that links this to the crisis in governance.

3 Research Methodology

This section outlines the method of research that was used to obtain the results of the study. It begins with sub-sections 3.1 and 3.2; a description of the data, the model specification as well as the methodology used to assess the research question. Sub-section 3.3 presents the results of the findings.

3.1 Conceptual Framework

In reviewing the Energy Plan outlined by the Department of Minerals and Energy to transform the energy industry, the following goals, and indicators will be analysed and where possible

these guidelines will be evaluated to measure the impact of political institutions on the efficiency of energy suppliers:

- Supporting economic growth and development.
- Improving the reliability of electricity infrastructure.
- Providing a reasonably priced electricity supply.
- Ensuring the security of electricity supply as set by a security of supply standard.
- Diversifying the primary energy sources of electricity.
- Meeting the renewable energy targets as set in the Energy White Paper (EWP).
- Increasing access to affordable energy services.
- Reducing energy usage through energy efficiency interventions.
- Accelerating household universal access to electricity.
- Clarifying some of the policy issues in the context of an evolving electricity sector (Department of Mineral and Energy, 2007).

3.1.1 Data

The beginning of 2021 saw a shift for most economies to achieve strong economic growth while trying to stay on track with the sustainable energy goals set by the International Energy Agency (IEA). This has reintroduced major challenges for most developing countries to transition to more renewable solutions. Coupled with increasing pressure to reduce carbon (CO^2) emissions and the subsequent rise in coal and fuel price, the transition seems more imminent. Thus, the main sample used to substantiate the discussion of this research will be obtained from the IEA's electricity database (IEA, 2022) as well as the World Bank's database on energy and economic indicators. Due to data availability, the sample is based on South Africa over a period of twenty years from 1999 to 2019. The sample will be used to construct a time series analysis that evaluates macroeconomic data to test the model that is identified below and to investigate the hypothesis that is presented in the study. As the motivation for this study stems from the political nature of South Africa's electricity supply, additional data from the World Bank database on governance indicators are included to allow for further analysis of the relationship between governance structures and electricity supply.

3.1.2 Model description and econometric specification

Despite the discussed definition of energy poverty, this research will make use of access to electricity excluding the affordability component as the dependent variable to measure the energy efficiency. This variable is defined as EP_t in the model. The main explanatory variable

for this study is electricity generated from renewable resources, RE_t. This variable comprises of electricity generation by sources such as hydro, biofuels, solar PV, Solar thermal, and wind. The additional independent variables are *NRE* and *mv*. The *NRE* variable is the counterfactual in the study. It represents non-renewable energy sources and is used to analyse the impact of electricity that is produced from other sources such as coal, oil, and nuclear. The variable mv represents the macroeconomic variables gross domestic product (*GDP*), inflation (*INF*), foreign direct investment (*FDI*), and unemployment (*UNEM*). The extension of the model includes a variable which is relatively important to estimate the relationship between governance structures and electricity supply. This is defined as the control of corruption (*CC*) which represents an estimated measure of governance. The two models may be defined as follows:

Equation 3.1: $$\boldsymbol{EP_t = \delta + \beta_1 RE_t + \beta_2 NRE_t + \sum_{i=1}^{I} \beta_i mv_t^i + \varepsilon_t}$$

Equation 3.2: $$\boldsymbol{EP_t = \delta + \beta_1 RE_t + \beta_2 NRE_t + \sum_{i=1}^{I} \beta_i mv_t^i + \alpha CC_t + \varepsilon_t}$$

where ε_t is the error term, *t* represents time (in years), and δ is the intercept.



Figure 3.1: Graphical representation of the main variables of interest.

Figure 3.1 illustrates the main variables of interest in the study where each graph represents the time series trend for each variable. The data in the graph indicates that between 1999 and 2019,

there was a significant decrease in the consumption of fossil fuel energy. The percentage of the population that gained access to electricity during the same time period also increased noticeably. In addition, with the exception of two notable fluctuations, the consumption of renewable energy has remained largely constant over time. While there was a sizable increase in renewable energy consumption in 2009, there was also a sizable decline in consumption in 2011.

3.2 Methodology

3.2.1 Unit root tests

To investigate the relationship of interest, a pre-analysis of the characteristics of the data series are examined by using unit root, augmented Dickey-Fuller (ADF), and structural break tests to ensure that the assumptions for modelling the regression are satisfied. The use of the ADF examines a null hypothesis of the presence of a unit root against stationarity by controlling of the issue of serial correlation that may appear in the series. The ADF method is a parametric approach which adds lag operators (augmenting). Additional Information Criteria, Akaike information criterion (AIC), pre-tests for modelling the data are conducted for identification of the series.

H_0: Unit root

H_a: Stationarity

3.2.2 Structural Vector Autoregression (SVAR)

The main results of this study will be derived from a Structural Vector Autoregression (SVAR) model which has come to be widely used in macroeconomics, for modelling and establishing relationships between economic variables bases on theoretical macroeconomic models. The structural interpretations of SVAR models require additional identifying assumptions that must be justified based on institutional knowledge, economic theory, or other external constraints on the model response (Kilian, 2013). Only after decomposing the forecast errors into mutually uncorrelated and economically interpretable structural shocks can we assess the causal effects of these shocks on the model variables. Thus, the SVAR model is used because it enables researchers to investigate causal relationships between variables. SVAR models provide insights into the cause-and-effect relationships among economic or time series data by identifying structural shocks and their impact on the variables of interest.

Consider a VAR model based on yearly data for $\boldsymbol{z_t} = (\Delta \boldsymbol{NRE_t}, \boldsymbol{RE_t}, \boldsymbol{EP_t})'$, where $\Delta \boldsymbol{EP_t}$ is the percent change in access to electricity. The structural VAR can be expressed as follows:

$$\boldsymbol{A_0 z_t} = \boldsymbol{\delta} + \sum_{\boldsymbol{i=1}}^{\boldsymbol{20}} \boldsymbol{A_i}\, \boldsymbol{z_{t-i}} + \boldsymbol{\varepsilon_t}$$

where A is the vector of eigenvalues and $\boldsymbol{\varepsilon_t}$ represents the vector with reduced form errors that are assumed to be serially and mutually uncorrelated structural innovations. Although it is generally difficult to interpret this in an economic sense, the structural analysis provides a reasonable explanation for what happens to $\boldsymbol{EP_t}$ if $\boldsymbol{RE_t}$ *or* $\boldsymbol{NRE_t}$ changes, holding everything else constant. Through the choleski decomposition and the inverse of the non-negative eigenvalues, we can obtain the reduced form errors as $\boldsymbol{e_t} = \boldsymbol{A_0^{-1}\varepsilon_t}$. This can further be written as follows:

$$\boldsymbol{e_t} = \begin{pmatrix} e_t^{\Delta NRE} \\ e_t^{RE} \\ e_t^{EP} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{non-renewable\ energy\ shock} \\ \varepsilon_t^{renewable\ energy\ shock} \\ \varepsilon_t^{access\ to\ electricity} \end{pmatrix}$$

This model suggests a vertical short-run curve for non-renewable energy policy. Shifts in the functions driven by the changes in renewable energy result in an instantaneous change in the access to electricity. In this case, the exclusion restriction is plausible because, in reality, an energy market like South Africa's would be slow to respond to policy changes, given the costs of switching between the various sources of energy and the uncertainty about the state of the energy market.

Despite the simplified nature of this study, the limitations arise from the calculation of political costs, as only a few quantitative assessments have been conducted to relate political costs to their impact on efficient power supply. However, the magnitude of these costs is estimated by giving a rough idea of the cost of policy implementation, the cost of managing the project, and the cost of financing projects. This is done as an estimate to relate the impact of political institutions on the efficiency of energy suppliers. This challenge may be overcome by using the control of corruption variable in the econometric analysis as an indicator for governance and proxy for the analysis of institutional factors affecting the electricity supply in South Africa. The study is also limited by the actual measurement of energy poverty and energy efficiency. Thus, it is only possible to use access to electricity as a proxy for the two indicators.

3.2.3 Impulse response functions (IRFs)

Castle and Hendry (2019) identify that estimation of the SVAR may face difficulties when the time series is nonstationary; if two unrelated time series are nonstationary because they change according to different events in the timeline, the correlation may appear to be misleadingly significant or false nonrejection of the null hypothesis may arise, making the mean and variances change over time. Thus, examining the IRFs is important in modelling the series. Access to electricity (a proxy for energy poverty) is modelled in this study to assess the policy shocks that occur due to the introduction of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The evidence of changes in the series may lead to insights on the varying reactions to the different policies that are implemented at each point in time. IRFs are particularly useful for investigating the interactions of variables in a VAR. They depict the variables' responses to shocks to the system. However, it is not always clear which shocks are appropriate for examining specific economic problems. To identify meaningful shocks, structural information must be used.

The analysis of the different responses to changes in a multivariate system is conducted by observing the graphical representations. Limitations identified are the validity of the results in the case of normally distributed errors for changes in the variances or covariances; however, testing for changes in the variances of the errors allows for observation of the parameters in the regression and first differencing if the variances appear to be changing overtime (Casini & Perron, 2018). The presence of stationarity means that the effect is short term, while the presence of structural changes means that the effects may be seen in the long run.

3.3 Empirical results

3.3.1 Unit root tests

As pre-tests for investigating the relationship between variables, we would benefit from understanding the trend properties of each variable, known as stationarity, to avoid spurious regression. For this paper, only the augmented Dickey–Fuller analysis is used. The ADF test suggested a robust OLS t-statistic, generalized least squares t-statistic based on the AR(p) process, and serial correlation which is controlled for in the test.

Table 3.1 shows the results from the lag selection. The lag selections of all tests were based on the Akaike information criterion (AIC). The AIC was selected because it attempts to balance model goodness-of-fit and model simplicity and generally favours models that adequately explain the data with fewer parameters. This helps you choose the number of past time periods

that should be included in the model. Thus, Table 3.1 indicates that two time periods should pass for the model to achieve stationarity.

Table 3.1*:* Results from Lag selection

Lag selection	AIC(n)	HQ(n)	SC(n)	FPE(n)
Lag Order	2	2	2	1

Table 3.2 shows the results from the ADF unit root test which indicates that we should not reject the null hypothesis for the variables energy poverty, renewable energy consumption, non-renewable energy consumption, GDP, inflation, foreign direct investment, unemployment, and the corruption control estimate, at a 1 percent level of significance. Thus, the series can be treated as I(1) process. This means that the structural VAR model analysis results may be obtained.

Table 3.2: Results of augmented Dickey-Fuller unit root test

	Value of test statistic	**P-value**
Access to electricity	1.591	0.306
Renewable Energy	0.175	0.960
Non-renewable Energy	-0.878	0.224
GDP	-1.298	0.244
Inflation	-1.084	0.565
Foreign Direct Investment	-0.738	0.204
Unemployment	-0.151	0.702
Corruption Control estimate	-0.814	0.025**
Significance codes: *** = 0.001 ** = 0.01; * = 0.05; = 0.10		

3.3.2 Structural VAR model

Table 3.3 illustrates the results from the structural VAR based on Equation 3.1, when the corruption control estimate is excluded from the analysis.

Table 3.3: Results from the SVAR

	Access to electricity	**Renewable Energy**	**Non-renewable Energy**	**GDP**	**Inflation**	**Unemployment**	**Foreign Direct Investment**

Access to electricity	1	0	0	0	0	0	0
Renewable Energy	0.009	1	0	0	0	0	0
Non-renewable Energy	0.122	0.061	1	0	0	0	0
GDP	-0.399	-1.372	-0.218	1	0	0	0
Inflation	0.632	-0.429	-3.019	0.919	1	0	0
Unemployment	0.0509	-0.002	0.079	0.004	0.021	1	0
Foreign Direct Investment	-0.369	-0.517	0.146	-0.514	-0.095	-0.187	1
Significance codes: *** = 0.001; ** = 0.01 * = 0.05							

The results indicate that access to electricity is positively affected by both renewable and non-renewable energy consumption. This means that a one percent increase in the consumption of renewable energy leads to 0.009 percent increase in access to electricity and a one percent increase in the consumption of non-renewable energy leads to 0.122 percent increase in access to electricity. This suggests that, compared to the use of renewable energy, the use of non-renewable energy has a stronger association with increased access to electricity in the short run. These results further indicate that non-renewable energy consumption has a greater positive impact on electricity access in South Africa while renewable energy consumption has a small positive effect on the welfare of South Africans. This might be because non-renewable energy sources are more dependable, making them more readily available to a larger population.

However, the analysis does not take into account all of the intricate dynamics in society. It is important to note that in the context of South Africa, multiple socioeconomic issues affect the relationship between access to electricity and the energy source from which the electricity is derived. A number of socioeconomic issues affect South Africa, such as gaps in infrastructure, access to education, and income inequality. These elements may have an impact on how energy use and access to electricity interact. Additional research should examine these socioeconomic issues and how they interact with energy policy and infrastructure development to gain a more thorough understanding.

Table 3.4 provides further analysis where a corruption control estimate is includes to the structural VAR model. The table illustrates the results from the structural VAR based on Equation 3.2, when the corruption control estimate is included in the analysis.

Table 3.4: Results from the SVAR including corruption control estimate.

	Access to electricity	**Renewable Energy**	**Non-renewable Energy**	**GDP**	**Inflation**	**Unemployment**	**Foreign Direct Investment**	**Corruption Control estimate**
Access to electricity	1	0	0	0	0	0	0	0
Renewable Energy	-0.067	1	0	0	0	0	0	0
Non-renewable Energy	0.124	0.105	1	0	0	0	0	0
GDP	-0.753	-1.510	0.469	1	0	0	0	0
Inflation	-1.020	-4.057	-3.037	3.333	1	0	0	0
Unemployment	0.087	0.104	0.077	-0.092	0.0057	1	0	0
Foreign Direct Investment	-0.087	-0.053	-0.077	-1.287	-0.187	-0.403	1	0
Corruption Control estimate	0.078	0.371	0.254	1.337	-0.005	-0.681	-2.883	1
Significance codes: *** = 0.001; ** = 0.01 * = 0.05								

The results indicate that access to electricity is negatively affected by both renewable energy consumption while access to electricity is positively affected by both non-renewable energy consumption. This means that a one percent increase in the consumption of renewable energy leads to 0.067 percent decrease in access to electricity. In contrast, a one percent increase in the consumption of non-renewable energy leads to 0.124 percent increase in access to electricity. The results also indicate that the inclusion of the corruption control estimate does not significantly change the relationship between non-renewable energy consumption and access to electricity. The positive correlation between non-renewable energy use and access to

electricity seems to be unaffected by the corruption control estimate. This suggests that non-renewable energy still has a positive impact on access to electricity even after taking corruption into account.

However, the inclusion of the corruption control estimate changes the effect of renewable energy consumption on access to electricity from a positive to a negative impact. These results further indicate that, in the presence of corruption, renewable energy consumption potentially reduces the welfare of South Africans. This implies that the relationship between the use of renewable energy sources and access to electricity may be altered by corruption.

3.3.3 Impulse Response Functions (IRFs)

The time path of the systemic shocks implied by the model is depicted in Figure 3.2. Figure 3.2 illustrates the response of access to electricity if changes in energy policies are implemented where graphs (a) and (c) represent policies changes when the corruption control is excluded and graphs (b) and (d) represent policies changes when the corruption control is included. Graph (a) indicates that a positive shock to renewable energy policies will decrease access to electricity in the first period. This decrease is not sustained as access to electricity increases in the following period and recovers to fluctuate around the zero levels. In contrast, graph (b) indicates that a positive shock to renewable energy policies is not likely to have an effect on access to electricity within the short run. However, it is possible that a significant decrease in access to electricity could occur in the long run.

Graph (c) indicates that a positive shock to non-renewable energy policies will result in a very small increase in access to electricity in the first period. However, in the next period a significant decrease in access to electricity occurs. This is followed by a recovery to the normal zero levels. In contrast, graph (d) indicates that a positive shock to non-renewable energy policies is not likely to have an effect on access to electricity within the short run. Additionally, it is possible that non-renewable energy policies are not likely to result in a significant increase in access to electricity in the long run.

In conclusion, these IRFs offer insights into how policies involving renewable and non-renewable energy affect people's access to electricity in the short and long run. Renewable energy policies may cause temporary disruptions, but the long-term effects on electricity access are more pronounced. Non-renewable energy policies temporarily improve access to electricity, but this effect is short-lived and does not last over time. The results highlight how crucial it is to carefully consider all factors and long-term effects of energy policies when

making choices about energy transitions and access to electricity. Resilience and sustainability over the long term are important issues that policymakers need to address.

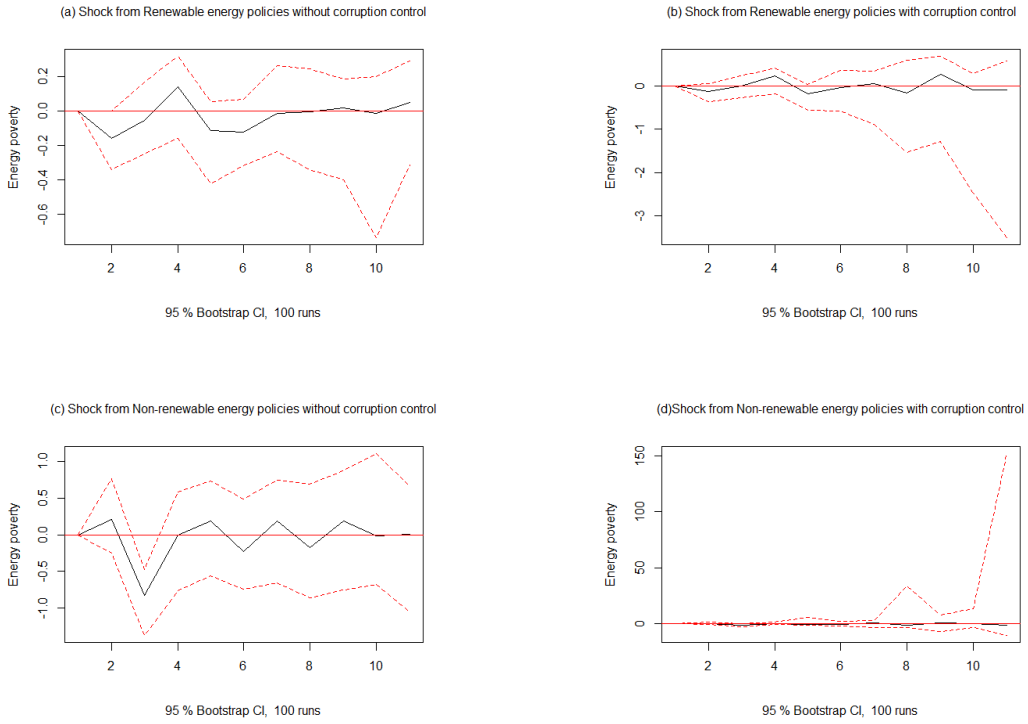


Figure 3.2: Impulse response functions of the shocks from renewable and non-renewable energy consumption on energy poverty.

However, it is important to note that, in graphs (a), (b) and (c), zero is within a relatively wide confidence interval. This means there is a relatively big margin for error and there could be no effect when there is a change in renewable energy policies. Whereas graph (d) has a very narrow confidence interval.

4 Discussion

South Africa has a wide range of renewable resources. Why then is South Africa not moving faster toward this new revolution? Is it due to a lack of funds, political uncertainty, or perhaps another factor? The answers appear to be in the social sciences rather than the technical world, and they have the possibility of addressing the needs of billions of people who do not have access to modern energy (Guruswamy, 2017). Furthermore, it appears that there are policy barriers preventing large-scale implementation of such technologies in that country.

This section further discusses the results obtained in subsection 3.3 and further. Sub-section 4.1 also expands on the political economic discussion to enhances the findings. Sub-section 4.1 also discusses the key policies related to the focus areas of access to electricity.

4.1 Situational analysis

4.1.1 Political environment

It was decided in 1948 that ten new power plants would be built to meet the country's industrial and mining demands. However, this capacity was still deemed insufficient in comparison to growth projections due to 5.5 percent economic growth and rising electricity demand at the time (Jaglin & Dubresson, 2016). Prior to 1987, keeping an arm's length relationship with the political sphere was an important part of maintaining Escom's autonomy. Despite pressure from Government and politicians, a clear distinction existed between politics, technology, and electrification.

When 1987 arrived, Eskom's technopolitical regime was realigned to promote market openness. Despite the debate for a more radical transformation, in the form of privatization, made in the Energy White Paper published in 1998, the reshaping proceeded. This privatization was delayed in order to maintain the political stability of the alliance between the ANC, COSATU, and the South African Communist Party (SACP), but the vertically integrated state monopoly was eventually retained.

Through the growth, employment, and redistribution (GEAR) initiative, which focused attention on developing into a competitive market player globally and was characterized by a reconstruction of the public sector, the ANC's process of neoliberal structural self-adjustment began in 1997. Further policy and strategy changes resulted in the New Growth Plan (NGP) in 2010 and the National Development Plan (NDP) in 2011. Conflicts within the alliance represented shifts in power and a shift toward state capitalism in South Africa's reform. Although this did not necessarily imply a complete shift away from neoliberalism, it did imply the deinstitutionalization of Eskom (Jaglin & Dubresson, 2016). With the passage of the Companies Amendment Act 3 of 2011, Eskom became one of the redefined state-owned enterprises (SOEs), as a result of changes in the company's governance systems, the establishment of a Board of Directors, a new company strategy, and the formation of an Executive Management Committee (Exco). Although modern state capitalism has proven more resilient, complex, and multifaceted than many previous challengers to the free-market economic model. State capitalism poses a serious challenge to free-market economics due to

its adaptability nowadays, as well as its traditional state economic planning with elements of free-market competition (Kurlantzick, 2016).

What distinguishes capitalism as a powerful mechanism for economic growth is not the government's ability to efficiently allocate resources, but the entrepreneurial ability to guide the introduction of very innovative products and technologies, thereby disrupting the existing equilibrium and bringing about dramatic change (Kanatsu, 2005). According to Kurlantick (2016), state capitalism presents potential challenges to society. The first challenge is that, in young democracies like South Africa, state capitalism could potentially put too much power in the hands of a few leaders and help corrode the democratic culture and institutions. The second challenge is that in state capitalists where political freedom has eroded, the breakdown can contribute to political instability. It is clear that a purely economic approach to solving South Africa's problems has not succeeded in improving the economic performance as it is a society in which the political and economic systems are in conflict (Burawoy, 1981). The third challenge is that in some of the most inefficient state capitalist countries, such as South Africa, economic weaknesses will be compounded, resulting in crises that will shock the economy. The ruling party, which presents itself as a representative of the socialist ideals, threatens the hegemony. Through economic regulation and the organization of class struggles, their economic planning not only protects but also advances the interests of the capitalist class.

The new governance structure meant that the state and politicians were able to intervene in the company's operations. Eskom's anticipated role as a developmental state instrument was supposed to provide economic stimulus through increased investment and improved electricity access, while also leveraging procurement for economic transformation. Another significant obstacle is now the lack of strategic direction experienced by South African major municipalities. They play an active, but often overlooked, role in electricity supply, sharing responsibility for distribution of electricity through urban areas with ESKOM. This role provides a valuable source of revenue for municipalities, which charge residents for the electricity they use. This revenue could account for one-third of the municipality's total revenue. According to Pegels (2022), fostering a favourable environment for renewable energy was not part of ESKOM's strategy.

While pro-poor incentives programs such as the Free Basic Electricity (FBE) intend to provide everyone with access to basic energy services, determining the number of people who benefit as well as the efficiency of such programs remains challenging for South Africa (Heinrich Boll

Stiftung, Sustainable Energy Africa, SAMSET, USAID, & Brot, n.d., p. 253). Furthermore, because there are no prescribed definitive implementation processes, municipalities mandated to implement these pro-poor subsidy programs are reported to be implementing them differently. As a result, the programs lose their intended value (DoE, 2014, p. 21). Moreover, it is also noted that some municipalities may not afford and therefore cannot provide such pro-poor subsidy programmes.

Because of its uncontrolled debt levels and inability to provide sufficient electricity to support growth, Eskom remains the single greatest risk to the South African economy (Department of Public Enterprises, 2019). Eskom has primarily survived on the back of strong Government support in the form of subordinated loans, direct equity injection and guarantees.

Eskom's financial sustainability is threatened by rising operating costs and cost overruns in the construction program. Over the last decade, coal costs have increased fivefold and payroll costs have increased three times. Debt service costs are expected to average R366.8 billion per year in the medium term, rising to R397.1 billion in 2025/2026. Since the Eskom debt relief agreement is a balance-sheet transaction, the government will face significantly higher borrowing costs (Mail & Guardian, 2023). However, in accordance with the budget, the government will service R184.4 billion of Eskom's debt over the next three years and will assume up to R70 billion of its debt in 2025/2026. As a result, the total amount borrowed will rise from R515 billion in 2023/2024 to R555 billion in 2025/2026. Managing Eskom's Debt.

As Eskom implements the structural, regulatory, and operational changes outlined in the "Roadmap for Eskom's Reform," ongoing liquidity and lender assistance will be critical. The South African government has already given assurances and demonstrated its willingness to support Eskom's liabilities within the country's fiscal constraints. Eskom's operational efficiency, cost structure, and income generation, on the one hand, and its potential financial sustainability, on the other, are interconnected. Any financial assistance will be conditional on Eskom taking the necessary and short - term steps to improve its current operational performance.

Frantz Fanon (2004), a believer of Marx’s theories, describes an environment that may be related to South Africa. He explains that the national bourgeoisie which is the class that takes overpower after independence does not take to his occupation to transform the nation but is more interested in serving the objectives of capitalism under the disguise of neo-colonialism. An interpretation of this class theory may be closely linked to the ANC in how it has assumed

leadership in South Africa. The ANC has displayed no vocation to improve the social development of the country, while serving the motives of a capitalist agenda within the state structures (Ukwandu, 2019).

4.1.2 Policy environment

In deciding on the policies and programmes that should be included when reviewing the underlying policy environment for achievement of specific targets, it is important to evaluate the integration within the National Development Plan (NDP) and the Sustainable Development Goals (SDGs) and the associated targets.

4.1.2.1 National development plan

The NDP is an overarching framework for the country's development strategy. The priority are the long-term prospects of eliminating poverty and reducing inequality by 2030 (Department of the Presidency, 2012). The NDP acknowledges unemployment targets for 24.9 per cent by June 2012, 14 per cent by 2020, and 6 per cent by 2030. This necessitated the creation of an additional 11 million jobs, bringing total employment from 13 million to 24 million. Since then, unemployment has risen and continues to be a burden on South Africa. The plan also acknowledges targets for real GDP to be 5.4 per cent on average by 2030. However, the South African government has yet to meet the targets. At this rate, it is unlikely that the current policy and strategy implementation path will result in the achievement of both local and SDG 8 targets by 2030.

Furthermore, adequate infrastructure investments in the energy sector are essential for the improvement of South Africans' livelihoods. In other words, a consistent supply of energy is critical for promoting economic growth and development, thereby contributing to the desired reduction in unemployment as well as the elimination of poverty and inequality. Similarly, global standards state that access to clean energy is one of the indicators of a developed nation. As a result, the NDP is integrated into SDG 7's focus areas of increased access to electricity, increased use of renewable energy, and promotion of energy efficiency.

The use of renewable energy and adaptation to cleaner energy sources such as gas has placed emphasis on the need to diversify the current energy mix and ownership in the electricity sector. The proposed diversification of ownership in the electricity sector would result in increased participation of (independent power providers) IPPs in the electricity market. The NDP suggests establishing an independent operator in charge of procuring and contracting IPPs as well as managing transmission assets. Such structural reforms would imply a more deregulation

energy market with diverse players, which could result in increased competition and, eventually, market determined pricing. However, it is worth noting that, so far, the proposed independent operator in the electricity market has yet to be implemented. Moreover, the electricity market is yet to improve the amount of electricity procured from IPPs.

4.1.2.2 Energy Policy (White Paper of 1998)

The White Paper on the Energy Policy is the first policy document detailing on energy development in the post-apartheid era (Mukonza & Nhamo, 2018, p. 25). The White Paper clarifies the government's position regarding the supply and consumption of energy in South Africa. Although the White Paper is more than twenty years old, it is still relevant and has been amended to include the White Paper on Renewable Energy which brought about the Renewable Independent Power Producer Procurement (REIPPP) Programme.

Given the energy crisis, urgent work is required to identify and assess the policy barriers that are preventing the country from achieving a sustainable supply of electricity. This entails prioritizing policy evaluation in the energy sector. Although it is critical to address the issues confronting the national electricity provider, Eskom, a greater emphasis must be placed on rectifying the entire electricity market. Eskom's indebtedness has become a serious macroeconomic risk, making it a precarious nexus for the circulation of public funds, while the high cost and unreliability of electricity has undermined South Africa's energy-intensive mining and industrial core.

Access to affordable energy services is prioritized in the energy policy objectives. The government has frequently committed to uphold and promote these policy goals. However, access to basic energy services for the majority of South Africans, as well as the poor and disadvantaged segments of South African society, has frequently fallen short. Although the White Paper provides a solid energy policy framework that is, to some extent, timeless in its ideology, the energy sector is highly dynamic. Some may be concerned that the scheduled review of the White Paper, which was due in 2008, has yet to be completed (Covary & Averesch, 2013, p. 594).

4.1.2.3 Renewable energy (White Paper of 2003)

In 2003, the White Paper on Renewable Energy presented a new framework to supplement the government's commitment to supporting the creation and execution of renewable energy projects. The REIPPP Programme is one of the most progressive and successful large-scale alternative energy programs in South Africa (GCIS, 2017, p. 6), with five cycles of bid

windows for private power producers to bid on supplying electricity, primarily renewable energy, to Eskom (Impact Amplifier, 2017, p. 10).

Despite the program's goal of improving access to electricity by increasing supply, there is an uneven balance between access to energy and the economic advantages of rising power investment opportunities in the energy sector. Thus, the interests of elite private organizations involved in key decisions on energy investment, technologies, and institutions are unlikely to align with those who lack access to energy or suffer the negative consequences of fossil fuel extraction, processing, and consumption. REIPPPP necessitates service providers to meet socioeconomic and community development criteria, as well as Black Economic Empowerment criteria (BEE). However, putting these into practice can be challenging. When the industry is overly competitive, not all developers collaborate with one another or with the government on socioeconomic issues. Furthermore, the South African business environment shows that ensuring universal access to certain services is not the primary goal of commercial developers whose business models are motivated by the desire for high returns in a short period of time.

Regardless of the progress made through the REIPPP Programme, the Program's future is under threat as a result of emerging challenges. Dispute from other segments of society, such as certain organized labour bodies that believe jobs associated with conventional energy sources such as coal will be lost as a result of the transition to renewable energy, is one example (Mukonza & Nhamo, 2018, p. 27). Despite the fears, this is not always the case. Because coal is still an important part of the transition, coal mines are likely to remain operational. However, alternative economies must be developed in areas where the transition will occur. The threat posed by Eskom as the vertically integrated firm may also have an impact on the program's success, as Eskom has previously failed to honour some of the program agreements as well as comply with ministerial determinations (WWF-SA, 2017, p. 30). Though this section covers a few of the main energy policies, South Africa has multiple comprehensive policies relating to promoting and ensuring the access to affordable, reliable, sustainable, and modern energy for all.

4.2 Recommendations

4.2.1 Greater coordination in government

The national government has frequently provided the necessary policy and regulatory frameworks to support the activity of SOEs, provincial and local governments. However, there

is most likely a lack of coordination within the government as well as a misalignment in the strategies presented by the various agents. Given the overlapping and concurrent responsibilities between spheres, coordination is critical. Thus, improved public administration and coordination by the government is a good place to start when it comes to improving growth.

Developmental policy framework should be classified inductively by how it is understood in a given situation by those implementing, assessing, or contesting and shifting policy (Fine & Seeraj, 2022). Policy has not produced the desired results for South Africa, as it has for other economies around the world. If the economy is not stimulated to achieve a balance of economic and social development, the effectiveness of the policies and systems in place can be called into question. The need for institutional coordination stems from the nature of the developmental state's task, which is to accelerate structural transformation (Chibber, 2002). The state needs to be considered responsible in some way to uphold the measures of discipline required to ensure that project implementation is successful.

4.2.2 Enabling environment for growth

In contrast to expectations, characterizing the South African economy's stagnation in recent years as the result of rent seeking leading to uncompetitive industries is not appropriate. Rent seeking does exist, but it is not the dominant character of business. Instead, the prominent characteristic of the modern era is the separation of the two. While the government remains heavily reliant on business in many ways, there has been a significant shift in the nature of South Africa's private sector. Because of the government's entrenched political involvement, the private sector appears to have reduced its reliance on intimate relationships with the government.

Attempts by the public sector to foster a business-friendly environment during the democratic transition did not establish an environment that encouraged domestic investment and innovation (Hirsch, 2021). Government initiatives to bridge the divide were not successful for a variety of reasons. For the time being, large South African corporations, while globally competitive, are becoming less politically and economically invested in South Africa.

Although the state’s role is important to cultivate economic growth, the political framework has often distorted the functions of the state, culminating into a bureaucratic system that is inefficient in the interventionist and management structures of the state. Governments should only intervene when there is a long-term interest in doing so, and it must be related to societal needs (Rodrik, 2011).

Rather than attempting to play a role in every facet of society, the government should focus on creating an enabling environment for policies and strategies to achieve the goals. Infrastructural development, market deregulation, and economic stability all contribute to an enabling environment. This would allow the private sector to engage in activities that improve economic conditions, such as job creation, increased competition, and achieving long-term economic growth. For the country to grow and develop at a steady pace, both the public and private sectors must work together in coherence as well.

4.2.3 Mitigation policy

Given the definition of energy poverty in **Error! Reference source not found.**, a clearer understanding me be derived on how to identify energy poverty in society. With this, knowledge may be applied in order to examine those energy poor communities and identify how energy poor they are. Energy poverty mitigation policies may then be considered that could target the most vulnerable energy poor households. This presents as an important point with the just transition so that no is left behind. Currently, FBE policy provides economically disadvantaged households with 50 kWh or more of free electricity per month as long as they have access to the grid; however, municipalities vary in terms of implementation (Ye & Koch, 2021). A significantly larger benefit according to research, is the contribution of renewable energy in the reduction of pollution at micro levels, while the relative severity of energy deprivation among households could be of interest to policy makers, because targeted interventions can be proposed.

4.2.4 Limitations

Given that the study's goal was to assess the impact of renewable energy transition on energy poverty, the study had data limitations as data on energy poverty was not available. South Africa, on the other hand, regularly tracks and measures data on access to energy sources such as electricity. As access to electricity is part of the definition, it was used as a proxy to measure energy poverty. However, it is unclear how the country is faring in terms of providing affordable, clean, and reliable energy to all.

It is suggested that future studies derive an energy poverty index which encompasses the complete definition of energy poverty where access, affordability and quality of energy is measured to formulate one variable. Ye and Koch (2021) derive an example of such a measure. They calculate this using Foster–Greer–Thorbecke (FGT) based poverty measures to examine energy poverty in South Africa. According to Ye and Koch, FGT measures a household-

specific energy poverty line using semiparametric estimation of energy spending shares, which is then used to calculate a household energy equivalence scale and, thus, the household specific required energy consumption level or poverty line. This measure provides a more comprehensive picture of energy poverty than binary indicators or multidimensional measures.

Although this study was unable to analyse the main forms of renewable energy, future research on the disaggregated effects of each energy source on energy poverty may be conducted. Furthermore, future research avenues may evaluate the long-term effects of a sustainable energy supply in South Africa.

5 Conclusion

In this paper, we examined how the dominant vertically integrated monopoly power provider in South Africa's electricity sector, Eskom, would potential be impacted by policies that promote renewable energy-based generation and thus harm the country's coal-based interests as well as the energy-poor South African population. We assessed the implications of policy changes to electricity generation in South Africa by employing an econometric analysis and discussion.

A recurring question in theoretical, empirical, and policy work is what effects of the shift towards renewable energy on the South African economy. The main objective of this paper was to examine the impact of renewable energy on energy poverty in South Africa. Annual time-series data for the period of 1999 to 2019 were investigated. The econometric approach employed in this study led us to the results from unit root tests which suggested that the series is dominantly I(1) model and thus would be stationary after first differencing. The results indicate that non-renewable energy consumption has a greater positive impact on electricity access in South Africa while renewable energy consumption has a small positive effect on the welfare of South Africans. However, the results indicate that, in the presence of corruption, non-renewable energy consumption has a positive impact on the welfare of South Africans while renewable energy consumption potentially reduces the welfare of South Africans. Moreover, the results from the analysis suggest that renewable energy projects conducted by the government are likely to be vulnerable to corruption and it is likely to have a negative influence on the access to electricity and thus the welfare in South Africa. The analysis suggests that existing approaches to transitioning from renewable to non-renewable energy must take into account the various developmental impacts.

In the context of a developing nation like South Africa, much of the responsibility for the stagnant development can be pointed toward the political interference, the refinancing of historic debt, and the failure to implement policy and strategy. The past energy crises have persisted in perpetuating the inequalities in developing countries. The inability of a development state to help steer the wheel of development and prosperity in the world is largely due to ineffective policies that are pushed in the developing countries. The challenge in the electricity market is having an indebted single vertically integrated monopoly that supplies electricity to entire country. Past literature has indicated that this challenge is a serious restriction on growth and development. The fact is that there are many challenges in the electricity sector and one solution cannot solve the problem. Without coordination, de-centralized activities can perpetuate the instabilities. It is evident that renewable energy is important to improve the sustainability and welfare of the country. However, non-renewable energy is still important for development and to maintain the growth of certain sectors in the country.

Because of low economies of scale and modern tech, companies offering green products seek assistance to reduce production costs, which is likely to change the consumption of renewable energy. Ordinary consumers regard expensive green products as luxury products reserved for the wealthy. As scarcity of resources and unsustainable problems emerge, green consumers and industries can help to facilitate a transition towards a Just Transition. This opens the door to incentives for dematerialisation and resource efficiency, which influence consumption patterns both directly and indirectly. Furthermore, the techniques developed may be applicable to a variety of transitional situations other than energy.

To achieve economic competitiveness, South Africa must integrate energy efficiency into existing energy generation and use systems, as well as new major infrastructure projects (Aliyu, Modu, & Tan, 2018). This could be accomplished by establishing policy and regulatory frameworks that promote energy efficiency while utilizing appropriate policy tools to facilitate success and effectiveness. The impact of climate change is an important concern that has prompted several initiatives to lower the emission of greenhouse gases (Jin & Kim, 2018). Some countries need to prioritize economic growth above all else, despite the international trend toward carbon reduction.

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