South Africa's Energy Policy: Prioritizing Competition and Climate Change for Decarbonisation

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Abstract

An affordable, reliable, and renewable power supply is essential for economic recovery and to ensure the economy reaches its potential output over the long term. The policy framework needs to catch up to the market's need for (i) competition to address increasing tariffs and the widening capacity shortfall and (ii) the increased role of renewable energy to facilitate the country's energy transition. This study examines how competition and climate change have influenced policy reform and implementation in the South African energy sector, by reviewing its historical context and regulatory framework. Furthermore, the study estimates the cost of neglecting these objectives in policy formation by assessing the impact on the energy system, the economy and the environment. The lifting of the embedded generation threshold policy reform, which will support climate and competition objectives, albeit after the fact, is expected to yield economic, social and environmental benefits. This study empirically demonstrates this by utilising the E3ME model developed by Cambridge Econometrics to support the case for the ex-ante prioritising of climate and competition considerations in energy policy. While energy security should remain the primary objective, energy policy can be leveraged to promote other government objectives, such as increased market participation and decarbonisation.

Keywords: Climate change; competition, energy policy; policy reform

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1. Introduction

Traditionally, electricity supply industries have been characterised by vertically integrated monopolies, as this structure was positioned to supply markets efficiently (Minnie, 2018). This required investments with the state's support enabled governments to drive public service and social objectives and ensured efficiency and security of supply from coordination of generation and transmission. However, the period over the 1980s and 1990s was characterised by the liberalisation of electricity markets worldwide, as the standard model of vertically integrated state-owned monopoly utilities was no longer suitable (ERSA, 2020; das Nair et al., 2014; Eberhard, 2004). There were many drivers for these reforms – with international trends in reforming the electricity markets placing greater emphasis on "competitiveness, efficiency and environmental sustainability" (Kessides et al., 2007).

South Africa's reform agenda is primarily reflected in three main developments: the establishment of an independent regulator, the National Electricity Regulator of South Africa (NERSA), in 1995; the corporatisation of Eskom (2001); and the introduction of independent power producers into generation (2011). However, despite these interventions, the more radical market reforms outlined in the 1998 White Paper on Energy Policy have not been implemented, including the restructuring of Eskom (Clark et al., 2005). It was not until recently that this reform was introduced and is underway. The government's explicit commitment to prioritising supply security has insulated Eskom's dominant position, having no real impact on competition and limiting the role of Independent Power Producers (IPPs) to government-run procurement programmes (Clark et al., 2005; das Nair et al., 2014).

The challenge is that entities under the current market arrangement of a vertically integrated monopoly are often prone to abuse monopoly power and inefficient performance from a lack of competition (Mondi, 2018). The failure to implement policy reform as outlined in the 1998 White Paper on Energy Policy has meant that Eskom's financial, operational and environmental performance has been dire. Not only has this had implications for the fiscus, but further costs have been imposed on the economy in the form of ongoing emissions and severe load shedding, which continues to intensify.

The recent lifting of the embedded generation licensing threshold will support decarbonisation efforts and promote competition in generation. It is expected to yield economic, social and environmental benefits.

This paper will empirically demonstrate these benefits, utilising the E3ME model developed by Cambridge Econometrics, by analysing the impact of adding more renewable energy over and above the national energy mix outlined in the Integrated Resource Plan (IRP) 2019. This demonstrates the ex-ante benefits prioritisation of climate and competition considerations in energy policy, aligned to the 1998 White Paper, could have yielded.

2. Review of energy policy drivers – The historical context and the current regulatory framework of the South African energy sector

The rationale for traditional monopoly market structure

Powerful sectoral configurations have developed as a result of the conception of electricity as a public infrastructure with natural monopoly qualities and the sector's organization into publicly owned or franchised institutional monopolies (Midttun, 1997). Historically, the global consensus on electricity supply was that vertically integrated monopolies could efficiently supply markets (Minnie, 2018). Under such a consensus, governments sought to address three market failures. First, the high capital cost associated with achieving scale economies in electricity generation, including tariffs that do not reflect operating and capital investment costs and the required sunk costs to establish distribution networks. Second, and more applicable to South Africa, the government sought to drive public service and social objectives by increasing the electrification of households from as early as 1922 and, more recently, during the post-apartheid era. Third, to ensure efficiency and security of supply, coordination between generation and transmission is necessitated to equate demand and supply – which governments enable through vertically integrated state monopolies (Minnie, 2018).

The standard model of energy sector reform

However, the period over the 1980s and 1990s was characterised by the liberalisation of electricity markets worldwide, as the standard model of vertically integrated state-owned monopoly utilities was no longer suitable (ERSA, 2020; Des Nair et al., 2014; Eberhard, 2004). The drivers behind the reform agenda over this period derive from several factors, including the need to correct for the inadequate performance of state-owned utilities (both operational and financial); the need to expand investments and capacity; and the restructuring of utilities to ensure efficient operation and reduction of fiscal impact (Eberhard, 2004). More generally, these international trends in reforming the electricity markets emphasised "competitiveness, efficiency and environmental sustainability" (Kessides et al., 2007). These reforms enabled the gradual reduction in the dominance of vertically integrated utilities by allowing for private sector participation. By 2012, only 6 per cent of the globally consumed energy was generated under a pure vertically integrated regulated monopoly (IEA, 2016). Kessides et al. (2007) note that while the common denominator in the transition has been the increased participation of private players, this has varied across countries.

The "standard model" for electricity sector reform, also recommended by institutions such as the World Bank, includes a suite of interventions aimed at achieving challenging the traditional market structure of vertically integrated state-owned utilities. Geddes et al. (2020) and Minnie (2018) categorise the key reform elements of the standard model into the following main broad categories: (i) creation of a system of independent regulation; (ii) promoting competition across the sector while recognising that transmission is likely to remain monopolised; (iii) restructuring the utilities by vertically and horizontally unbundling into independent corporatised entities; and (iv) encouraging private sector investment in new infrastructure and privatisation of existing assets. Teljuer et al. (2016a) add (i) commercialisation as a means to introduce cost recovery and (ii) the passing of requisite legislation to provide for the legal mandate to restructure and introduce private participation and ownership into the market. Jaccard (2007) adds to the requirements under the standard model elements of (i) creation of spot markets for real-time system balancing, and (ii) to separate competitive and regulated costs and prices, unbundling retail tariffs. All these elements encompass components of the standard model of reform, which countries have employed with variation based on primary objectives sought by underlying policy and the nature of electricity systems (IEA, 2016).

The IEA (2016) notes that the ultimate degree of market liberalisation occurs when retail competition is added to wholesale markets. Moreover, the IEA (2001) differentiates between vertical integrated monopolies and the standard reform model, which it refers to as retail competition. It provides that "*Retail competition combines deregulation, lifting constraints on the potentially competitive activities in the ESI, with re-regulation of the network and related activities which remain monopolistic. This combination of full market opening, unbundling of* *transmission activities, regulated access to the network and liberalisation of electricity trade is known as "retail competition*" (IEA, 2001). It acknowledges that most approaches to reform can be considered as some form a constrained version of the retail competition model.

The sequence and experience of reform for countries has varied, where some countries have unbundled vertically integrated utilities with partial privatisation, while some have introduced private participation in electricity generation. Other countries have undertaken full privatisation and the introduction of private participation in generation. Some of the key characteristics of the early reformers include (IEA, 2001):

- Independent regulation was introduced in the United Kingdom (UK), Sweden and Australia, including the requirement for competition enforcement in Australia.
- In the UK, Norway, Sweden, Australia and New Zealand, there was (i) unbundling of generation from transmission; (ii) regulated third-party access to the grid[1] and (iii) full consumer choice was targeted. However, vertical integration of generation and distribution was only implemented in Norway and Sweden. Only the UK had private ownership of utilities. Germany, Italy and Portugal adopted single buyer models.
- With respect to the establishment of wholesale markets, the UK, Australia, New Zealand and members of the NordPool[2] established the pool participation, which was only mandated in the UK and Australia.
- Outside the EU, the US has also been ahead in terms of implementing reforms. Wholesale open access rules for transmission owners were issued, with the creation of independent system operators encouraged (was not mandated) to avoid discrimination. Supply choice for consumers has also been enabled through regulation, by supporting competition in generation. The reforms have also concentrated on the mitigation and compensation for stranded assets attributed to investments in nuclear generation and in long-term power purchase agreements.
- Argentina vertically and horizontally unbundled and further privatised state-owned generators and distributors into a disintegrated structure in which no generator would have a market share larger

[1] This excludes New Zealand, where third-party access to the grid is negotiated.
[2] NordPool is a voluntary electricity exchange comprising traders from Norway, Sweden, Finland and parts of Denmark.

than 10 per cent. The country also established wholesale markets for electricity based on private participation. Transmission and distribution largely remained regulated.

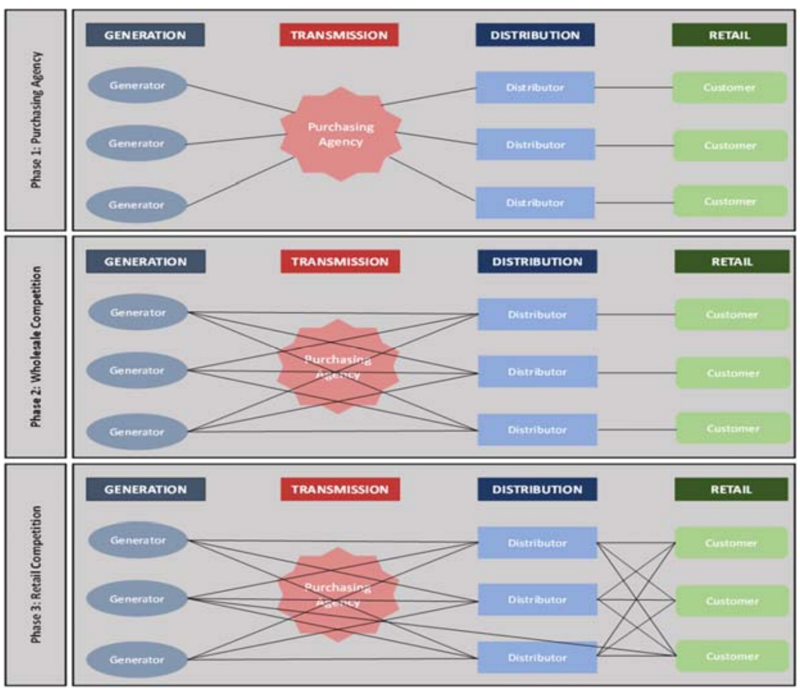
Eberhard and Kapika (2013) that note the emerging structure of the power sector in much of sub-Saharan Africa is the creation of hybrid markets which are characterised by dominant incumbent state-owned utilities operating alongside independent power producers. This result is further confirmed by Urpelainen and Yang (2019), who find that many developing countries have adopted hybrid variation of the standard model. However, to achieve this degree of market liberalisation, Urpelainen and Yang (2019) posit that unbundling is critical in ensuring retail competition. They argue that unbundling is a necessary step towards privatisation and liberalisation, as for instance, privatisation of a vertically integrated entity creates a private monopoly which retain similar challenges and will therefore not foster competition (Urpelainen and Yang, 2019).

Competition in electricity markets

The level of competition and government control in electricity industries varies across economies. Ljung (2007) notes that this is often a function of the objectives and modalities of the reform agenda, with additional constraints in attracting private investment and limiting competition. Minnie (2018) and Teljeur et al. (2016b) categorise the models of competition into three phases (Figure 1), which follow from the implementation of the critical components of the standard reform model. Phase 1, known as the single buyer model, allows for competition at the generation level by creating a centralised purchasing agency. The purchasing agency can exist in a market with a vertically integrated utility or in an unbundled system where the state-owned utility is vertically separated, and several independent generating companies are created (Ljung, 2007). In the former case, the state-owned utility will purchase power from IPPs through long-term contracts, while in the latter case, the power from generators is dispatched by the purchasing agency based on price. In addition to the autonomous generators, vertical separation of the state-owned utility will include separating distribution into regional entities and retaining transmission under a monopoly structure (Minnie, 2018). This initial phase is considered an interim phase for introducing competition and creates the foundation for transitioning into the latter two phases (Teljeur et al., 2016b).

The second phase creates wholesale competition where multiple distributors can interact directly with power generators and compete for generated electricity (Teljeur et al., 2016b). Competition occurs between electricity generating companies competing for contracts with distributors, which requires unbundling to have been achieved, along with introducing a regulatory authority (Ljung, 2007). Contracting in the market can occur under negotiated contracts or through the spot market (Minnie, 2018). The final phase introduces competition at the retail level – extending the competition to every vertical level of the electricity supply chain. Teljeur et al. (2016b) identify this as the ideal market model, where in addition to the wholesale competition, distributors and/or retailers can compete for end-users of electricity. Under this phase, the transmission entity is considered a "common carrier" of electricity for market participants. It should undertake this service at a regulated fee and independent of the other state-owned entities (Ljung, 2007).

Figure 1: Models of introducing competition in electricity markets



Source: Minnie (2018) and Teljeur et al. (2016b)

While the effectiveness of the standard model in developing and emerging economies remains a subject of debate, the World Bank finds a positive correlation between private sector participation and economic efficiency improvement (Geddes et al., 2020). Furthermore, since the development of the prescripts of the standard model, many economies have had to place social and environmental impacts alongside economic considerations, extending the reform response. (Geddes et al., 2020).

South African historical context

Before 1994, South Africa's public energy policy aimed to provide cheap electricity for industry and high-income households, excluding most of the population. In the early 1990s, the focus shifted to electrifying previously excluded households and consolidating electricity distributors for better performance. The National Energy Regulator was established in 1995 to issue licenses, approve tariffs, monitor quality of supply, and settle disputes. (Kessides et al, 2007; Eberhard, 2004; Clark et al., 2005).

However, the need for reform of the South African electricity sector was (formally) recognised in the 1998 White Paper on Energy Policy (White Paper) (Teljeur et al., 2016, DME, 1998). The White Paper created the foundation to prioritise environmental sustainability and ensure the security of supply through diversity in the generation. In particular, the policy pronounced the government's support for a competitive electricity market with a restructured Eskom. Renewable energy was also recognised for its role in remote areas and how it could be the least-cost energy service, particularly when social and environmental costs are included (DME, 1998). The vision for the electricity sector espoused in the policy was for the vertical and horizontal unbundling of the sector to enable the separation of competitive and natural monopoly components of the industry; the introduction of competition; non-discrimination, and open access to transmission and the introduction of independent regulation (Eberhard, 2004). Therefore, from a policy perspective, South Africa has always been positioned to transition the electricity sector and attain efficiency, increase competition (resulting in increased investment and capacity), and realise benefits related to climate change (environmental sustainability).

Many reform proposals in line with the White Paper faced resistance and were never implemented (Eberhard, 2004; Teljeur et al., 2016). Those that were implemented are:

- **1995: Establishment of an independent regulator**. The National Energy Regulatory (NER) (and later the National Energy Regulator of South Africa (NERSA)) was established in terms of the

Electricity Act of 1995 to, among other things, grant licenses and determine tariffs (Teljeur et al., 2016).

- **2001: Corporatisation of Eskom**. Eskom corporatisation sought to reform the entity's governance and create a greater emphasis on its commercial imperatives (Clark et al., 2005). As a result, Eskom would be subject to taxes and dividends to the government as the sole shareholder (Teljeur et al., 2016).

- **2011: Introduction of independent power producers**. The competitive bidding process for renewable energy projects was developed in 2011 by the Department of Energy. The programme has gone through four major bidding rounds, and 6 323 MW of electricity has been contracted from 92 IPPs (IPP Office, 2021).

Despite these interventions, the more radical market reforms outlined in the White Paper had not been implemented, including restructuring Eskom and permitting open, nondiscriminatory access to the transmission system (Clark et al., 2005). First, the corporatisation of Eskom was not the result of policy developments in the energy sector but instead of a broad agenda by the Department of Public Enterprises (DPE) to restructure state-owned enterprises (SOEs) (Eberhard, 2004). The introduction of independent power producers (IPPs) through the Renewable Energy Independent Power Producer (REIPPP) programme has also come with its challenges. In 2007, Eskom was designated the single power buyer from public and private producers. This led to the holdup in the programme when Eskom refused to sign power purchase agreements from the programme (das Nair et al., 2014; Minnie, 2018). Thus, despite the implementation of the programme (which some may argue has been successful), the role of IPPs has been limited, and this has had no real impact on competition (das Nair et al., 2014).

In 2001, Cabinet approved a set of proposals for the managed liberalisation of the electricity supply industry, including (i) Eskom retaining a market share of no less than 70 per cent, with vertical unbundling to ensure non-discriminatory and open access to the transmission lines, (ii) the introduction of a multi-market model electricity market framework; and (iii) regulation that will enable participation of IPPs and diversify the energy mix (Clark et al., 2005). The decision to pre-determine Eskom's market share was the result of

Eskom's disapproval of the proposals to reduce its market share to around 35 per cent (Eberhard, 2004). In the years following this, the energy mix remained coal-dominated, and the role of IPPs was limited.

Several other White Paper-aligned reforms went through phases of proposal and resistance – sometimes going as far as the development of required legislation – ultimately failing to be adopted. These include the development of six Regional Electricity Distributors (REDs) in 2001 to rationalise distribution and separate it from Eskom; the introduction of a multi-market model for electricity trading proposed by DME in 2003, and the unbundling of Eskom, which was to be facilitated by the Independent System and Market Operator (ISMO) Bill in 2011 (Teljeur et al., 2016a). The Bill was centred around the removal of the operation of the electricity grid from Eskom into an independent, state-owned entity (National Treasury, 2020).

The challenge with South Africa's electricity reform is that the government has traditionally prioritised the security of supply over other objectives. In 2004, when the White Paper proposals should have been implemented, the Minerals and Energy Minister stated in parliament that "the state has to put the security of supply above all and above competition especially." (Clark et al., 2005). While this core objective is essential, energy policy can be mobilised to achieve secondary goals. The lack of ex-ante prioritisation of other policies in the South African market has meant policy reform is driven by a response to the crisis instead of international precedence to a phased approach to reform, recognising the failures of the traditional model of vertically integrated state monopolies.

Climate change considerations in the course of policy development and reform

South Africa's national climate change governance has been cross-cutting across all sectors, specific sectors such as energy, industry, agriculture and waste. The cross-cutting and energy policies are summarised in the table below. According to Averchenkova et al. (2019), the foundation for South Africa's climate policy is found in the 2004 National Climate Change Response Strategy and the 2011 National Climate Change Response White Paper (NCCRWP). The NCCRWP sets out guiding principles for climate change, outlining priorities for adaptation and mitigation for a long-term transition to a climate-resilient, low-carbon economy and society (Kiss-Dobronyi et al., 2021).

Table 1: Summary of climate change policy – cross-cutting and at the energy level

	2004	2008	2009	2011	2012	2015	2018	2019
Cross-cutting	National Climate Change Response Strategy			National Climate Change Response White Paper	National Development Plan	Nationally Determined Contribution to Paris Agreement	National Climate Change Bill	Carbon Tax Bill
Energy		National Energy Act	Non-renewable electricity levy	SANS 204: Energy Efficiency in Buildings Integrated Resource Plan for Energy (2010-30)	Section 12L of the Income Tax Act			Integrated Resource Plan for Energy

Source: Averchenkova et al., 2019

Climate change policy reform in the energy sector has experienced similar challenges concerning policy design, priority challenges and delays in adoption. In terms of sector-specific interventions, we highlight some challenges:

- The government's flagship programme for adaptation and mitigation, the REIPPP programme, was successfully implemented at a small scale relative to the overall energy mix, which has not materially changed the share of renewable energy in the broad energy mix. The programme also faced delays when Eskom delayed signing PPAs as the designated buyer of privately generated electricity (Averchenkova et al., 2019).

- Since the introduction of Minimum Emissions Standards[3] to be effective in 2015 by the Department of Environmental Affairs (DEA), Eskom has applied for two 5-year postponements and has not fully complied with the regulations since their inception (Euripidou et al., 2022). Furthermore, the programme has faced an approximate 5-year interruption between bid windows four and five that the DMRE launched in 2021.

[3] In Eskom's case, these include concentrations of sulphur dioxide (SO2), oxides of nitrogen (NOx), and particulate matter.

- The introduction of the Carbon Tax has also allowed for deductions in the rates and phased implementation of the tax. Under the first phase of the tax (1 June 2019 to 31 December 2021), transitional support measures were implemented, such as the electricity price neutrality commitment enabled through the environmental levy offset (National Treasury, 2022; KPMG, 2022). Phase 1 measures will be extended to 31 December 2025.

- South Africa's updated Nationally Determined Contribution (NDC), approved by Cabinet in 2021, implies that most of the mitigation in the economy will come from the electricity sector, with an almost linear relationship between national greenhouse gas emissions and electricity sector emissions (Steyn & Tyler, 2021). The challenge is this will require an accelerated decommissioning of coal plants, low utilisation of the coal fleet and substantial renewable energy (Steyn & Tyler, 2021). This will require an update to the IRP, mainly to reflect the necessary renewable energy.

Recent reforms

In the State of the Nation Address of 2019, President Cyril Ramaphosa announced that "*To bring credibility to the turnaround and position South Africa's power sector for the future, we shall immediately embark on a process of establishing three separate entities – Generation, Transmission and Distribution – under Eskom Holdings*" (SONA, 2019). The government formally re-introduced the policy of unbundling Eskom to facilitate the 9-point plan the entity had introduced to address its challenges. The Department of Public Enterprises (DPE) then published a roadmap (Eskom Roadmap) outlining Eskom's restructuring and role in a reformed electricity supply industry. In presenting this plan, the DPE acknowledged, among other things, the risk presented by the lack of diversification in generation (DPE, 2019). Moreover, as far as the structure of the sector was concerned, the DPE noted that (i) Eskom's business model was outdated and (ii) Eskom's monopoly prevented innovation and the ability of Eskom to embrace technology disruptions (DPE, 2019). DPE (2019) has further recognised the following benefits from the electricity supply industry restructuring: increased competition in generation and drive compliance with environmental legislation and policy.[4] After

[4] In line with the Roadmap, Eskom has completed the (i) divisionalisation and appointment of divisional boards and heads and (ii) functional separation within three divisions. Eskom is currently in the process of legally separating Transmission into a wholly-owned subsidiary of Eskom.

the Eskom Roadmap, the DMRE has published draft amendments to the Electricity Regulation Act (ERA) – which will enable a competitive electricity market, alongside unbundling of Eskom and the establishment of an independent transmission company (Operation Vulindlela, 2022).

Amendment of Schedule 2 of the ERA removed the licensing threshold for embedded generation projects, facilitating private investment at scale and increasing the role of IPPs outside the government's procurement programmes. Furthermore, the DMRE issued New Generation Capacity Regulations in terms of the ERA to enable municipalities (in good financial standing) to procure power directly from IPPs. These two reforms aim to facilitate excellent private-sector investment in electricity generation. Draft amendments to Electricity Pricing Policy and NERSA's electricity pricing framework have been proposed. They form part of the suite of regulations that require alignment with a reformed electricity supply industry. In relation to climate policy, South Africa revised its Nationally Determined Contribution (NDC) in 2019. Cabinet approved South Africa's updated climate change mitigation up to 2030 (Steyn & Tyler, 2021). Furthermore, Eskom has developed its Just Energy Transition (JET) plan. Its strategic objectives include accelerating the repurposing and repowering of power stations; fast-tracking the execution of renewable energy; and ensuring a positive social impact through local manufacturing and job creation (Eskom, 2021c).

Finally (and more recently), the President announced a suite of interventions to address the current energy crisis (Ramaphosa, 2022). While the measures are aimed at arresting load shedding and resolving the immediate capacity shortfall, some will have implications for the structure of the electricity supply industry. This includes the removal of a licensing threshold for embedded generation projects and passing legislation for streamlining relevant processes and required exemptions for renewable energy projects (Ramaphosa, 2022). While it should be noted that there are challenges with implementing the standard reform model, as models of wholesale and retail competition are complicated and complex to implement, and the circumstances and constraints faced by developing countries are fundamentally different (Teljeur et al., 2016b). South Africa is recognised as a laggard in the electricity sector reform, and policy efforts over the past three years are characterised by a response to the crisis – mainly deriving from the failure of Eskom.

3. Costs of neglecting climate and competition objectives in energy policy

3.1 Financial failure

South Africa's dominant governance paradigm suffered from monopoly failure in which the vertically integrated, state-owned monopoly Eskom was positioned to realise scale economies and drive industrial policy. Entities under such a paradigm often abuse monopoly power and inefficient performance from a lack of competition (Mondi, 2018). This is evident in the performance of Eskom from a financial, operational and environmental perspective. According to the Parliamentary Budget Office's (2017) report on Eskom's financial position, profitability has been declining since 2007/08 – with profit margins averaging 4 per cent relative to highs of 15 per cent in 1994/95. This was not the result of declining revenues, which continued to increase despite slowing economic growth and the introduction of load shedding (PBO, 2017). Over this period, Eskom reversed the trend of low electricity tariffs that fell in real terms (PBO, 2017).

Before the onset of load shedding, pre-2007, the price of electricity did not reflect the actual cost of generating, transmitting, and distributing power and reached an all-time low by 2007 (Nova Economics, 2020). Eskom heavily subsidised electricity, crowding out the private sector investment for electricity generation. Two critical changes in the electricity landscape facilitated the reversal in the tariff trajectory: a difference in the tariff-setting methodology and the timing of Eskom's investment in the new build programme. The cost of electricity has since risen substantially, with the average electricity price increasing by approximately 400 per cent since 2008.[5] Despite the allowance for the return of tariffs to cost reflectivity by 2013, this has not been the case (PBO, 2017). More recently, this has been evidenced by a consistent divergence in the tariff applied for by Eskom and approved by the regulator NERSA (Eskom, 2021c). These inadequate tariff increases add to Eskom's under-recovery costs, which are also driven mainly by rising municipal debt, loss of revenue and high-cost structure.

While it can be argued that external dependencies drive the municipal debt and level of approved tariffs, other factors have contributed to the entity's financial liquidity constraints. These include Eskom's cost structure (driven by, among other things, primary energy contracts, labour costs, etc.) and the ballooning

[5] Data source: Statssa (The average price of electricity, c/kWh)

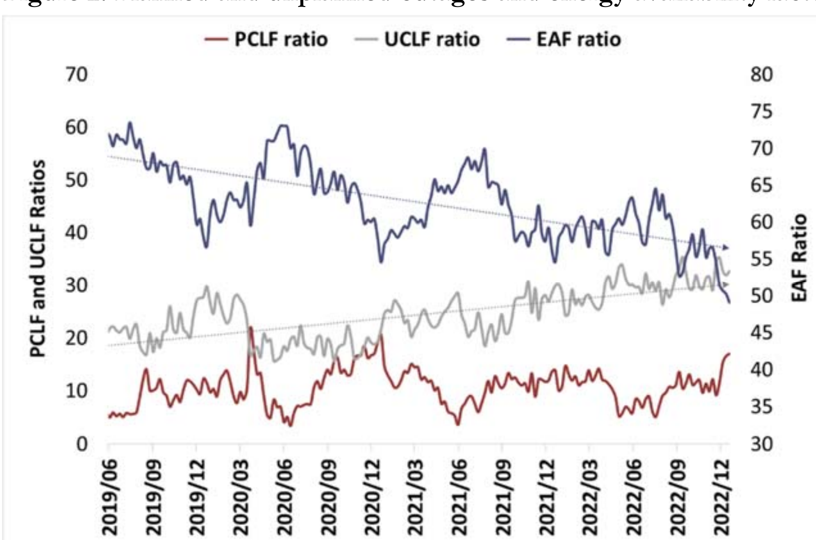
costs for the new build programme. This has necessitated government support to ensure the entity's going concern status and ability to service its debt (Eskom, 2021a). In their annual results for the financial year that ended March 2022, Eskom reported a 1 per cent reduction in gross debt, facilitated by government support of R31.7 billion (Eskom, 2022). More specifically, since the 2008/09 financial year, the government has provided Eskom with R263.4 billion bailouts (National Treasury, 2023). Furthermore, in his 2023 Budget Speech, the Minister of Finance announced that over the next three years, the government would be taking over R254 billion of Eskom's outstanding debt (Godongwana, 2023). The debt relief programme aims to strengthen Eskom's balance sheet as it undertakes restructuring into generation, distribution and transmission and broadly enables the entity to undertake the required maintenance (National Treasury, 2023).

3.2 Energy system failure

The South African energy system has been constrained with intermittent power outages crippling the economy since 2007. The market structure of a coal-dominated energy mix, with a vertically integrated, state-owned monopoly, has resulted in unsustainable energy and inadequate and unreliable electricity supply. The steady downward trend of the energy availability factor (EAF), measuring the difference between the maximum energy available and unavailable due to outages expressed as a percentage, reflects the worsening plant performance over time. The EAF decreased from 78 per cent in 2017 to 58 per cent in 2022, well below the 74 per cent target (Eskom, 2018, 2022). The declining EAF has been predominantly a result of an ageing and deteriorating coal fleet and subsequent unplanned outages. Eskom (2022) attributes the causes of deterioration in the fleet's performance to a lack of sufficient generation capacity, aggravated by equipment age, insufficient funds for maintenance and additional system space. The average age of the coal fleet, excluding Medupi and Kusile, is 42 years across Eskom's 15 power stations, of which many have become unreliable due to age and lack of maintenance. Furthermore, the construction of Medupi and Kusile, which started in 2007, was expected to add almost 10 GW to the grid; however, construction has been significantly delayed, and design defects resulted in sub-optimal performance, exacerbating the constraints to the system.

Figure 2 depicts the Unplanned Capability Loss Factor (UCLF), the Planned Capacity Loss Factor (PCLF) and the Energy Availability Factor (EAF) of the Eskom plant. UCLF is the ratio between the unavailable energy of the units that are out on unplanned outages over a period compared to the total net installed capacity of all units over the same period. This provides an indication of unplanned outages or generation units being out of service due for repairs or maintenance due to unplanned event or breakdowns. It is evident that they have been trending upwards, signalling the deterioration of plant performance and Eskom's inability to meet demand. Eskom has faced severe operational challenges, quality concerns, and a shortage of resources to undertake planned capital spending and maintenance, resulting in worsening unplanned outages (Nova Economics, 2020; Eskom, 2019). The Energy Availability Factor of the Eskom plant is the difference between the maximum available capacity and all unavailable capacity expressed as a percentage. The EAF has been trending downwards implying less energy available and more power outages as a result of high unplanned outages of power plants. Eskom (2022) reported that the electricity supply shortfall is approximately 6 GW, likely to persist over the next five years if action is not taken to add new capacity to the grid. Similarly, Meridian Economics (2022) empirically shows that 5 GW of additional renewable capacity would have reduced load shedding by 96.5 per cent in 2021.

Figure 2: Planned and unplanned outages and energy availability factor ratios

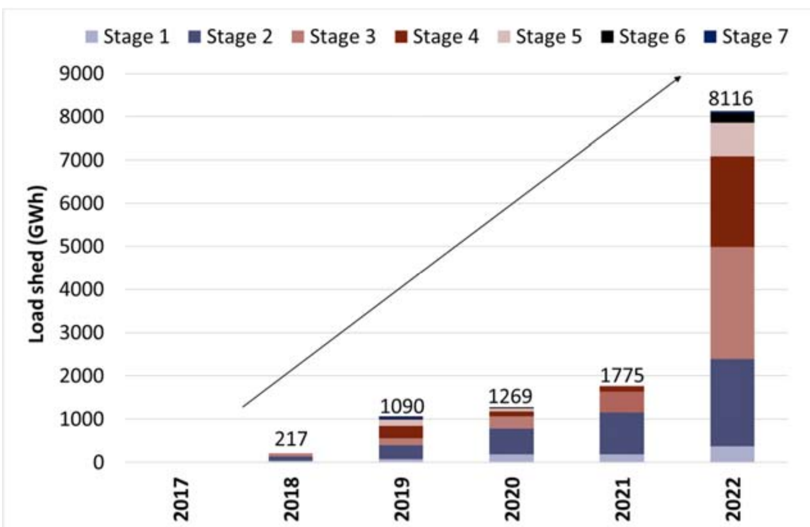


Source: Eskom data from the weekly Eskom system status reports

Notes: UCLF refers to the unplanned capacity loss factor; PCLF refers to the planned capacity loss factor

The worsening outages and limited new generation capacity added to the grid have culminated in a vulnerable energy system with constant load shedding paralysing the economy. The 2022 load-shedding capacity amounted to 8116 GWh, approximately 350 per cent above the 2021 capacity and the worst year on record. This translates into 3782 hours of load shedding compared with 871 and 1165 hours in 2020 and 2021, respectively.[6] Around 10 GW of Eskom's base-load capacity will be decommissioned in the next decade, adding additional strain to the already vulnerable energy system and exacerbating the need for new generating capacity (Eskom, 2021). Failing to sufficiently and timeously ramp up renewables in the energy mix and introducing competition in the market has led to an over-reliance on ageing large-scale coal-fired power plants and ultimately reducing the energy security of South Africa at a high cost to the country. The current IRP 2019 does not sufficiently consider other government objectives, such as increased market participation and the energy transition, calling for an urgent revision.

Figure 3: Load shedding (GWh) by stage of load shedding



Source: Authors' calculations, based on Eskom hourly data
Note: Calculations are based on hourly data; load shedding is assumed to have occurred for the entire hour load shedding was implemented and reported. A standardized terminology is used in South Africa to describe the stages of load shedding based on the CSIR methodology. In order to prevent a total blackout, Eskom, the national power utility, must withdraw a certain amount of power from the grid at each stage. For example, Stage 1 calls for the removal of 1000 MW, Stage 2 calls for the removal of 2000 MW, and so on to Stage 8, where the removal of 8000 MW is called for. Depending on the actual demand and supply at the time of the outage, the real amount of load shedding needed may be less than the theoretical value at each stage. The stages are based on a "rolling blackout" strategy, in which different locations are impacted at various periods to lessen the impact on crucial infrastructure and services. The CSIR methodology is used to establish a uniform framework for comprehending and

[6] See Appendix, data source: Eskom (Manual Load Reduction (MLR), GW/h).

expressing to the public and stakeholders the seriousness of load shedding, as well as to direct the adoption of suitable actions to manage the electrical supply and demand balance.(CSIR, 2021).

Nova Economics (2020) determined the impact of load shedding on the economy. The study estimates that 1 per cent load shedding as a percentage of electricity sales leads to a 0.4 per cent decrease in GDP. It is furthermore inferred that a full day of stage 1 load shedding would cost the economy around R235 million, while the cost of stage 4 is almost a billion. The study estimates that the cost of load shedding to the South African economy over the 12 years between 2007 and 2019 was nearly R35 billion. The cost of load shedding for 2020 and 2021 is estimated at R12 billion and R18 billion, respectively (Creamer, 2022). The cost of load shedding for 2022 is estimated to be between R240 billion and R690 billion, anticipated to rise even further in 2023 owing to worsened load shedding intensity.[7]

3.3 Environmental failure

South Africa's economy continues to rely on fossil fuels as a source of energy – with 90 per cent derived from fossil fuels (DEA, 2017). This is because coal remains a primary source for our electricity generation mix, providing around 80 per cent of generation capacity (Pierce & Ferreira, 2022). In 2018, the electricity (and heat) sector contributed over 50 per cent of the carbon dioxide (CO_2) emissions in South Africa. It, therefore, remained an essential industry for targeting decarbonisation (Kiss-Dobronyi et al., 2021). Pretorius et al. (2015) find that during the earliest period of South Africa's energy crisis, emissions increased as energy demand was met by delayed maintenance resulting in increased utilisation of the generation fleet. In particular, between 2007 and 2010, particulate matter almost doubled; between 2006 and 2012, CO_2 emissions increased by 15 per cent, reflecting the impact of the energy crisis.

Despite promulgating the Minimum Emissions Standards (MES) by the DEA for effect in 2015, Eskom continues struggling to contain and meet emissions standards. In terms of the National Environmental

[7] The Department of Mineral Resources and Energy and the National Energy Regulator use a measure of the cost of Unserved Energy (COUE) to estimate the impact of load shedding on the economy. The last published figure is estimated to be about R85 per kilowatt hour (kWh).. On the other hand, the Cost of Load shedding (COLS) calculates the cost when the timing and duration of outage is known, reflecting the impact of adaptation. The current cost range is based on a COLS of R29.05/kWh and a COUE of R85/kWh respectively .

Management: Air Quality Act, 2004 (Act No. 39 of 2004), all Eskom coal and liquid fuel-fired power stations are required to comply with MES requirements contained in government regulations (Eskom, 2020)[8]. These requirements are outlined in Eskom's Atmospheric Emissions Licenses (AELs), which is held for all power stations, and specify permissible emission concentrations of sulphur dioxide (SO2), oxides of nitrogen (NOx), and particulate matter[9]. While emissions have fallen by over 92 per cent between 1982 and 2021, emissions levels increased at the onset of the energy crisis and have remained relatively stable since then (Eskom, 2021). These levels, albeit historically low, significantly contribute to the country's overall emissions. Following promulgating the Minimum Emissions Standards, Eskom applied for its first postponement to comply with the emissions standards. Eskom noted that they would adopt a phased approach to compliance due to a number of factors, including the remaining life of plants, excessive financial, outage, and resource requirements for 100 per cent compliance (Eskom, 2016).

Ahead of the 2020 compliance deadline, Eskom further applied for a combination of postponements, suspensions of compliance, and alternative (weaker) limits in relation to emissions standards (Euripidou et al., 2022). This included an exemption application for compliance with MES. Six power stations were suspended, another three were granted 5-year postponements and no alternative limits were approved (Euripidou et al., 2022). In its decision, the National Air Quality Officer noted that "*Eskom has made minimal effort to comply with the standards fully", and "[t]he NAQO does not have the prerogative to issue decisions that are outside the current legal provisions or are in non-compliance with the law*" (Euripidou et al., 2022). In appealing the decision, Eskom has indicated that the cost of full compliance is estimated to be around R300 billion and approximately 16 000MW of nominal generation capacity will be at risk if alternative limits are not granted (Eskom, 2021a). The current energy crisis may exacerbate the extent of Eskom's non-compliance. Eskom's average plant energy utilisation factor (EUF) – which measures the extent to which a plant is run when it is available – has been increasing and has now breached 90 per cent relative to 85 per cent in 2010 and 80 per cent in 2000 (Eskom, 2021b, 2022). Environmental challenges continue, as reported by Eskom,

[8] Notice no. 893 dated 22 November 2013, and as amended in government notice no. 1207 on 31 October 2018

[9] See Eskom website: https://www.eskom.co.za/dataportal/emissions/

including poor emissions performance and deterioration in water consumption, including criminal court proceedings (Eskom, 2022).

Maintaining a market structure that limits private participation and renewable energy has resulted in an inadequate, unsustainable, and unaffordable electricity supply. The persistent and worsening power outages call for an expansion in electricity capacity and decarbonisation of the sector. Security of the electricity supply is the cornerstone of economic growth, and accelerating the decarbonisation of the electricity sector that supports a just transition is paramount to the country's climate and social objectives. The electricity landscape envisioned would embody an environmentally sustainable electricity structure that encourages private participation, strengthens competition in the sector, and is supported by a sound policy framework and efficient administrative system.

4. Benefits of prioritising competition and climate considerations: An Impact Analysis

Affordable, reliable, renewable power supply underpins efficient operations and sustained economic growth. It also contributes to the country's international competitiveness and cushions the effect of potential trade pressure, such as the Carbon Border Adjustment Mechanism (CBAM) under the European Green Deal, in which emissions and carbon tax exposure may be assessed across the entire supply chain. The South African energy sector is transforming significantly by introducing competition to the energy market (Operation Vulindela, 2022). In August 2021, Schedule 2 of the Electricity Regulations Act (ERA) was amended, raising the licensing threshold for embedded generation from 1 to 100 MW. During the announcement of the energy reform, President Cyril Ramaphosa noted that "*this decision reflects our determination to take the necessary action to achieve energy security and reduce the impact of load shedding on businesses and households across the country*." More recently, the President announced that the licencing threshold would be removed altogether. Once the ERA has been amended accordingly, projects must only register with the regulator, irrespective of the project size.

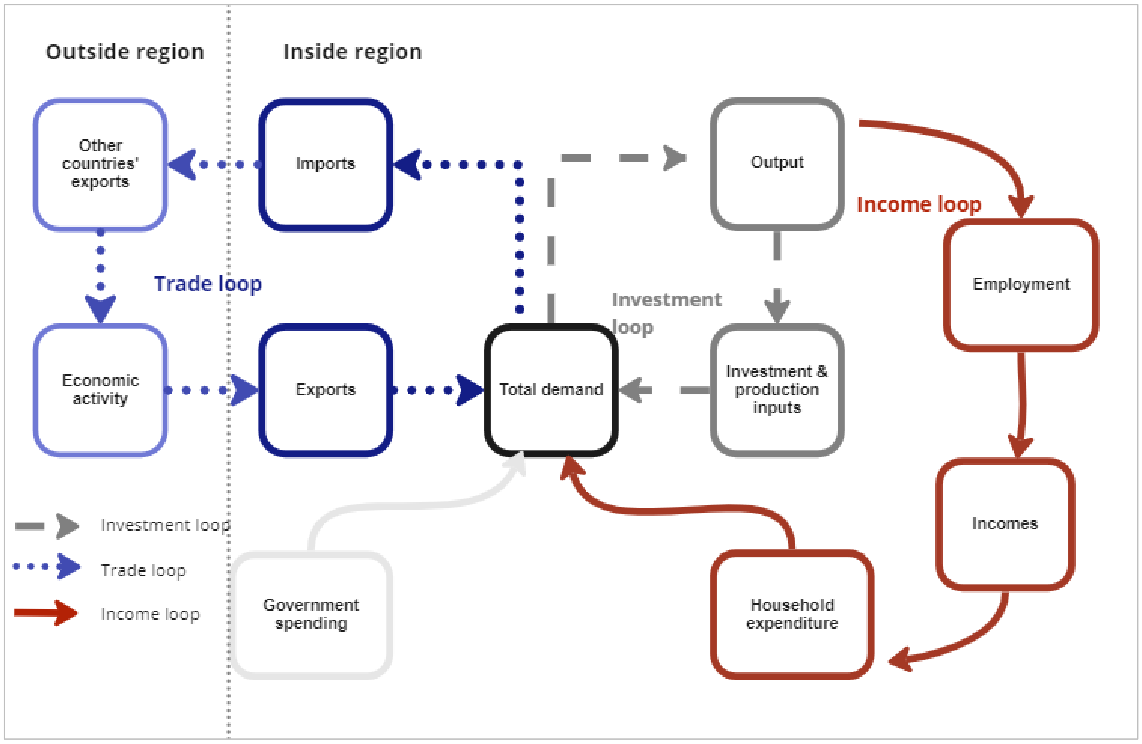
The energy sector has recently undergone rapid reform in response to the energy crisis in South Africa. While climate and competition considerations were not the main drivers of the reform, they are expected to have positive impacts. Amendments to Schedule 2 of the ERA are expected to promote private investment in energy generation and encourage renewable energy projects, contributing to energy security. The resulting benefits will be demonstrated empirically in the paper.

4.1 Background to the E3ME model

This study presents the potential impact of the embedded generation energy policy reform through scenario-based analysis, utilising the E3ME model developed by the European Commission and Cambridge Econometrics. We determine the impact of additional renewable capacity due to the energy policy change. This widely used dynamic, structural, global macroeconomic model is well suited for analysing the impacts of Energy-Environment-Economy (E3) policies by allowing two-way linkages between the energy system, environment, and economy, the three components of the model. The modelling approach is based on the national accounting framework disaggregated into 43 industries and 29 stochastic equations sets by employing cointegration and error-correction methodology. This allows for analysing interactions between the components, investigating short-term dynamics and assessing the longer-term impacts of policies.[10] The main difference between E3ME and Computable General Equilibrium (CGE) models is the assumptions about optimisation. While generally, with CGE models, behaviour is determined through an optimising framework, E3ME determines behavioural factors empirically (Cambridge Econometrics, 2019).

[10] The E3ME model manual provides a detailed description of the model, data sources and inputs, software, econometric specifications and modelling approaches. The manual and additional information pertaining the model is available from: www.e3me.com.

Figure 4: E3ME's economic module



Source: Cambridge Econometrics E3ME manual (2019)

Some of the equations of interest are outlined in the Appendix, and the complete set of 29 behavioural equations can be obtained from the Cambridge Econometrics manual (2019). These equations model the interdependent loops in the economic module of the E3ME model as follows, as outlined by Cambridge Econometrics:

- Interdependency between sectors: If one sector increases output, it will buy more inputs from its suppliers, who will purchase from its suppliers. This is similar to a Type I multiplier.
- The income loop: If a sector increases output, it may also increase employment, leading to higher incomes and additional consumer spending. This feeds back into the economy, as given by a Type II multiplier.
- The investment loop: When firms increase output (and expect higher levels of future output), they must also increase production capacity by investing. This creates demand for the production of the sectors that produce investment goods (e.g. construction, engineering) and their supply chains.

- The trade loop: Some of the increased demand described above will be met by imported goods and services. This leads to higher demand and production levels in other countries. Hence there is also a loop between countries.

The Future Technology Transformations for the Power sector (FTT: Power) module determines a technology mix by region given a scenario of electricity policy. Changes in the power technology mix result in changes in production costs, reflected in the price of electricity. The paper will determine the impact of the energy policy change that increases renewable energy generation and, therefore, changes in the technology mix. In the E3M3 model, an exogenous capacity addition to the power generation sector gets treated in E3ME in the following way i) investment need is calculated and added as an investment for the power generation sector, feeding into the economic module ii) it is assumed that investment is financed from new sources and therefore there is no within or cross-sector crowding-out.

4.2 Constructing the scenario

The E3ME model's baseline reflects the latest official energy policy, the IRP 2019. To determine the impact of the energy policy change, a scenario is constructed that adds embedded generation renewable energy capacity to the baseline, after which the effect on various economic, social, and environmental indicators is determined. To create the EG (Embedded generation) scenario, the expected additional capacity due to the energy policy change needs to be determined. A survey based on 239 industry players indicated that an estimated 5 GW of additional capacity could be added over five years in the residential, commercial, industrial, and agricultural sectors (Steyn & Renaud, 2021). Furthermore, the most recent 3Q2022 Operation Vulindela progress report reports that more than 100 projects are in development, representing a combined capacity of over 9 GW. Considering the approximate timelines for obtaining approvals to register a project and the construction time, this additional capacity is expected to be added incrementally over the medium to longer term.

Most embedded generation investments will likely combine solar PV and wind investment due to their cost advantages (Meridian, 2022). The cost of renewables has fallen significantly in the past decade, supported by improving technologies, economies of scale, competitive supply chains, and improving developer experience and is likely to continue to decrease over time as technology improves (Irena, 2021; Hartley et al., 2019). Renewables have become more cost competitive compared with new coal and to the operating cost of existing coal plants (Merven, Burton & Lehmann-Grube, 2021).

The National Business Initiative (NBI) studied the least-cost power system and found that a least-cost pathway will consist of a renewables-dominated power system by 2050 (NBI, 2021). The study estimates that at least 4 GW of renewables will be installed yearly for South Africa to reach net zero by 2050. The current IRP 2019 reflects only approximately 2.3 GW of additional capacity on average per year between 2022 and 2030. The NBI study recommends that by 2030, additional renewable capacity be increased from 20 GW to at least 30 GW to achieve net zero by 2050.

Figure 5: Electricity capacity (GW)

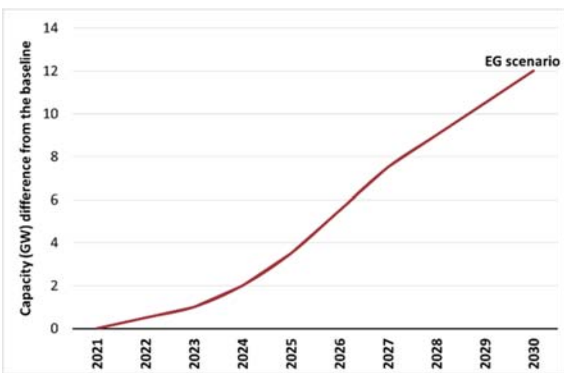
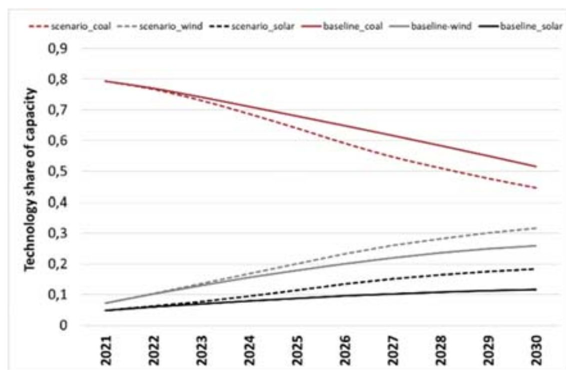


Figure 6: Electricity technology share of capacity



Source: E3ME modelling

Note: The share of each technology is relative to the total electricity capacity. The shares of coal, solar and wind would therefore not add to 100 since there are other technologies, such as nuclear and pump storage, that are not included in the graph.

Figure 5 depicts the assumed expected additional renewable- solar and wind-embedded generation capacity to the baseline due to the energy policy reform. The scenario assumes that the capacity combines wind and solar and that there is some initial lumpiness in response to the policy change and normalisation in additional capacity added after that. An additional 6 GW is expected to be added between 2022 to 2026, such that, in total, the scenario assumes 12 GW of renewable capacity over and above the level outlined in the IRP 2019 is added by 2030, also in line with the Operation Vulindlela projections and NBI (2021) recommendation.

Figure 6 illustrates the share of the capacity of coal, solar PV, and wind of the baseline compared to the EG scenario over time in relation to the total electricity capacity. In 2021, coal-fired power generation dominated the electricity mix and accounted for around 80 per cent of electricity generated, while renewable sources accounted for approximately 12 per cent (Pierce & Ferreira, 2022). The percentage of coal decreases in both the baseline and the policy scenario but to a greater extent in the EG scenario. Similarly, the share of solar PV and wind capacity increases incrementally in both the baseline and the scenario, with the percentage of solar PV capacity reaching 18 per cent compared with 11 per cent in the baseline by 2030. The share of wind capacity will reach 31 per cent by 2030 under the scenario compared with approximately 25 per cent in the baseline. .[11]

4.3 Empirical results

It should be noted that the projections and simulation results are quantified estimates of the impact of the policy reform on the various indicators and should not be interpreted as predictions. As such, the generally accepted method of reporting the impact of the policy change on economic, social, and environmental indicators is different from the baseline (Cambridge Econometrics, 2019).

Figure 7: Economic Activity (GDP)

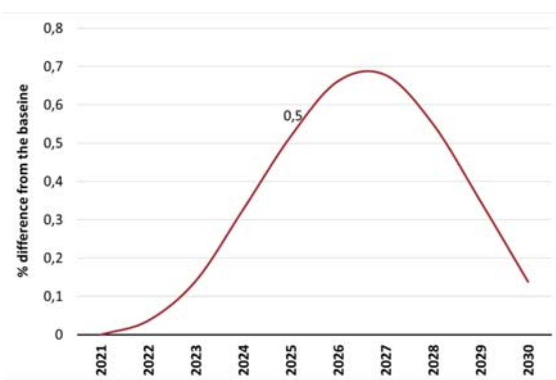
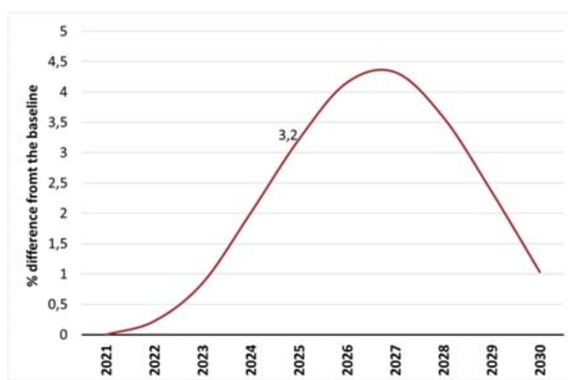


Figure 8: Investment (GFCF)



Source: E3ME modelling

[11] While Figures 5 and 6 depicts the difference between the baseline and scenario electricity capacity as well as the shares the of the technologies under the baseline and scenario; the actual capacity under the baseline and scenario is included in the Appendix.

Figure 7 illustrates the impact of the policy reform on economic activity and can be interpreted as the percentage difference from the baseline. By 2025, GDP is expected to be 0.5 per cent higher than the baseline. The minor impact in the outer years reflects the relatively higher initial investment in response to the policy but also a higher baseline in outer years based on the current energy planning. From the model output the impact of the policy reform is modest, however when considering that the South African economy grew by a mere 1.9 per cent in 2022, 0.5 per cent above the baseline by 2025 is notable. Nonetheless, this points to the need for additional drivers to reduce emissions and support a renewable energy transition such as the materialising the $8.5 billion pledged at the COP26 climate change conference in Glasgow in 2021 to accelerating South Africa's Just Energy Transition. Hartley et al. (2019) employ the SATIMGE model, a combination of the South African TIMES (SATIM) model (integrated energy systems model) and the eSAGE model (CGE model), to illustrate the impact of renewable energy on growth and employment. The study shows that a shift to renewable energy generation positively affects development due to lower electricity investment requirements that limit the crowding out of economic investments and lower electricity prices.

The energy policy reform will support investment in renewable energy. Figure 8 depicts the impact of the embedded generation scenario on investment. From Figure 8, it can be deduced that, as a result of the expected additional embedded generation capacity, the investment will be 3.2 per cent higher than the baseline by 2025. The Minerals Council (2023) expects investment in excess of around R100 billion and 6.5 GW of additional privately funded, renewable energy capacity from the mining sector alone in short to medium term.

Figure 9: CO_2 emissions

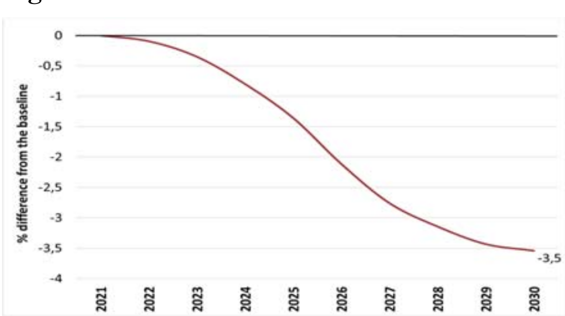
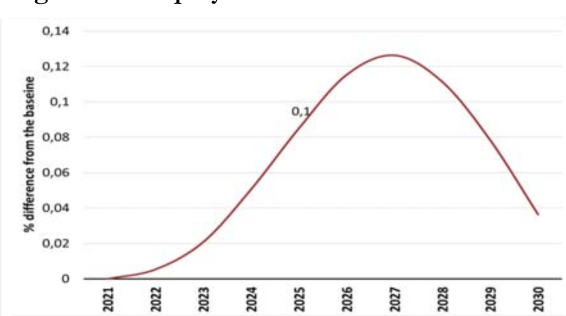


Figure 10: Employment



Source: E3ME modelling

Environmental benefits are expected from renewable energy embedded generation Figure 9 above shows that CO_2 emissions may decrease by 3.5 per cent by 2030 compared with the baseline due to the policy change. Increased renewable capacity through embedded generation has the potential to contribute notably to the energy transition and, as discussed before, is considered one of the main suggestions to reduce emissions and deal with climate change. It should be noted here, however, that the emissions reductions are not evenly distributed among the different energy sources. A possible reason that this fact may be attributed is the plant Energy Utilisation Factor (EUF). Energy sources characterised by intermittency (such as wind and solar) usually have lower EUF values than conventional power plants. Their capacity requirements thus to meet the same levels of demand are higher, resulting in higher capacity costs. On the other hand, conventional power plants run continuously, generating an electricity supply that is more reliable and consistent. Therefore, despite the significant increase in wind and solar shares in the electricity supply, the emissions reduction is not equally substantial across all energy sources. the features and regulatory frameworks of the individual energy systems may affect the influence of the EUF on emissions reduction. For instance, integrating energy storage technology can improve the flexibility and dependability of intermittent sources by raising their EUF. Furthermore, regulations like carbon pricing and renewable energy standards can encourage the use of low-carbon energy sources and ease the entry of those sources into the market.

Not only is the expansion of renewable energy capacity expected to contribute to the energy transition, but also the just transition and yield social benefits. Figure 10 shows the potential employment benefits of lifting the licensing threshold for an embedded generation. By 2025, employment is expected to be 0.1 per cent higher than the baseline. This translates into at least 15 000 additional jobs added compared to the baseline by 2025.

A phase-out of coal power generation threatens the livelihoods of thousands of individuals in the coal mining value chain. Renewable energy technologies can improve vulnerable groups' resilience and diversify and bolster the economy (TIPS, 2020). Studies have shown that renewable energy has a net positive impact on employment (Hartley et al., 2019; Merven et al., 2021). Although employment benefits are likely skewed towards individuals with secondary and tertiary education, lower-educated workers are also expected to benefit. Furthermore, employment gains are expected predominantly in the electricity, manufacturing, and service sectors (TIPS, 2020; Hartley et al., 2019).

Although an energy transition is expected to have a net positive effect on employment, the decommissioning of coal power stations and the shift to greener energy domestically and globally will disrupt the coal value chain. Given these realities, strategies on the coal value chain and energy transition, such as the Eskom JET strategy, are crucial to ensure that the transition is and will not negatively impact society or livelihoods. Future research could study the distribution of these employment gains to determine who will benefit from the transition and assess whether it can be considered a just transition.

4.4 Impact of energy sector reforms on tariffs

The model results do not allow for assessment on the impact of increased private generation on tariffs; however, we draw on literature and country experiences to infer on the expected impact on tariffs from market restructuring. From a theoretical perspective, the microeconomic impact electricity sector reforms should be to lower electricity costs and retail prices while improving the overall efficiency of the sector, given their reliance on competition and price signals (Jamasb et al, 2015). The entry of new market players, with more efficient technologies can create downward pressure on prices (Jamasb et al, 2015). Under the South African government's REIPPP programme, the average tariff per bid round has consistently fallen since the start of the programme (Independent Power Producer Office, 2021). The competitive bidding process along with leveraging off cheaper technologies has supported these price reductions.

Despite this expectation, the results on the impact of energy sector reforms on tariffs is mixed and underlies country specific factors and market arrangements. The IEA (2001) reports mixed results for early adopters of energy sector reforms, including price reductions in the early days of reform owing to price wars in the case of Germany and Spanish government's agreement with industry to gradually decrease tariffs. In the case of Australia, large price drops were reported at the wholesale level, while in Carlifornia, price reductions were reported at the onset of competition however with increased volatility particularly in periods of high demand (IEA, 2001). Jamasb et al (2015) reports of studies that have found that the introduction of foreign IPPs, privatization and introducing retail competition lowered electricity prices in some regions and not all, with regulatory institutions of developing countries found to have not been independent and therefore impacted on cost reflectivity of tariffs. Another study also found that vertical unbundling decreased electricity tariffs by 10% indicating a higher degree of competitiveness in developing countries (Jamasb et al, 2015). These results are in line with other study findings reported by Jamasb et al that:

- The participation of IPPs at the generation level and the existence of wholesale markets correlated with a decrease industrial price-cost margin in Latin American countries;
- Establishment of wholesale electricity markets and a regulatory agency had a downward effect on residential price-cost margins in developing countries; and
- Unbundling, inherent to the retail competition model, with privatisation, also contributed to a decrease on residential price-cost margins in the developing countries in the Latin America.

However, given that sector reforms are also expected to promote cost-reflectivity of tariffs, they can have the unintended outcome of initially raising end user tariffs in the short run, also critical for attracting private investment (Jamasb et al, 2015). This is particularly prevalent in African countries, where tariffs are either very low and below the cost of service or very high relative to the quality of service (Eberhard, A and Kapika, J., 2013). Jamasb et al (2015) reports of a study that found that electricity sector liberalisation in Asian developing countries reduced cross-subsidisation while not reducing average electricity prices. This can be a preliminary expectation of the tariff trajectory in South Africa, which is in line with the regulator NERSA's proposal to amend tariff methodology principles to ensure cost-reflectivity among other things (NERSA, 2022). That is, the removal of subsidies, a source of inefficiency, and move to cost reflectivity will result in increased prices. Despite this, the expectation is that over time, tariffs will improve as expected from the impact of competition. The lower cost of renewable energy is also expected to support these tariff declines.

5. Conclusion and policy implications

Overall, the policy framework needs to catch up to the market's need for (i) competition to address increasing tariffs and the widening capacity shortfall and (ii) the increased role of renewable energy to facilitate the country's energy transition and climate objectives. Failing to sufficiently and timeously ramp up renewables in the energy mix and introducing competition in the market has led to an over-reliance on ageing large-scale coal-fired power plants and ultimately reducing the energy security of South Africa at a high cost to the country. The energy sector has undergone rapid reform in the past couple of years.

Renewable energy is increasingly becoming an important topic in research for sustainable development. Increasing embedded generation from renewable sources is sufficient but not sufficient condition for the transition to more competitive market environments, not a conclusive indicator on its own. However, the nature of the renewables vis-à-vis conventional generation of electricity makes the case of embedded generation from renewables leading to more competitive markets stronger. However, the market's level of competition and innovation may be influenced by regulations governing how embedded generators are connected to the grid, pricing schemes for selling excess electricity, and financial incentives for making investments in renewable energy sources. When developing and putting into practice policies to encourage a competitive and sustainable electricity market, decision-makers and industry stakeholders must consider various factors and trade-offs.

Exploring the case of renewables, Bohlmann et al. (2019) studied the employment and economic growth effects of South Africa's transition to a low-carbon energy supply mix. Their findings suggest that the transition can result in net increases in employment and economic growth, especially in the renewable energy sector. Similarly, Inglesi-Lotz (2016) found a positive relationship between renewable energy consumption and economic growth. These studies provide evidence that transitioning to a low-carbon economy can have positive economic outcomes. Additionally, a policy brief by UP-GIZ (2022) highlights the importance of transitioning to a low-carbon economy for sustainable development in South Africa. The brief recommends policy interventions to promote renewable energy, energy efficiency, and green skills development. Therefore, it is clear that transitioning to a low-carbon economy is important for sustainable economic development, and policy interventions are required to support this transition.

Although ex-ante climate and competition considerations do not seem to have been the key drivers of this energy policy reform, instead, a response to the energy crisis, ex-post competition and climate benefits are expected. The empirical results demonstrate the benefits of climate and competition considerations, albeit de facto ex-post in this case, as illustrated by lifting the embedded generation threshold and supporting the claim for ex-ante prioritising climate and competition considerations in energy policy. While energy security should remain the primary objective, considering and leveraging other government objectives, such as increased market participation and the energy transition, while formulating policy is crucial.

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Appendix

E3ME model data sources:

Variable(s)	Data source	
	Historical data	Baseline forecast
Population	UN	IMF WEO (short-term) IEA WEO CPS (medium-term) IIASA SSP2 (long-term)
National accounts data	UN	
Labour force & employment	ILO	
Bilateral trade	OECD STAN	
Energy demand	IEA	IEA WEO CPS
CO_2 emissions	EDGAR	

*Refer to the Cambridge Econometrics manual (2019) for the full list of data sources for all the countries.

Sector disaggregation: 69 economic sectors in Europe and 43 sectors for other countries.

Equations sets:

Below are some of the equations of interest obtained from the Cambridge Econometrics manual (2019). For the full set of equations and additional detail, please refer to the Cambridge Econometrics manual (2019).

<u>Output equation</u>

Co-integrating long-term equation:

LN(YRN) = BYRN + BYRN * LN(YRY) + BYRN * LN(YRX) + BYRN * LN(YKNO) + BYRN * LN(YCAP) + ECM

Dynamic equation:

DLN(YRN) = BYRN + BYRN* DLN(YRY) + BYRN * DLN(YRX) +BYRN * DLN(YKNO) +

BYRN * DLN(YCAP) + BYRN * DLN(YR)(-1) + BYRN * ECM(-1)

BYRN	matrix of parameters
YRN	matrix of normal industrial output for 69/43 sectors and 61 regions
YR	matrix of gross industry output for 69/43 industries and 61 regions
YRY	matrix of average industrial output (excluding own sector) for 69/43 sectors and 61 regions
YRX	matrix of average industrial output (excluding own region) for 69/43 sectors and 61 regions
YKNO	matrix of the knowledge stock for 69/43 industries and 61 regions
YCAP	matrix of the capital stock for 69/43 industries and 61 regions

*Detailed sectoral disaggregation, with 69 economic sectors in Europe and 43 sectors for the rest of the countries

Investment equation

Co-integrating long-term equation:

LN(KR) = BKR +BKR * LN(YR) + BKR * LN(PKR/PYR) + BKR * LN(YRWC) + BKR * LN(PQRM) + ECM

Dynamic equation:

DLN(KR) = BKR + BKR * DLN(YR) + BKR * DLN(PKR/PYR) + BKR*DLN(YRWC) + BKR * DLN(PQRM) + BKR * LN(RRLR) + BKR * LN(YYN) + BKR * DLN(KR)(-1) + BKR * ECM(-1)

Identities:

YRWC = (YRLC/PYR) / YREE

RRLR = 1 + (RLR – DLN(PRSC)) / 100

BKR	matrix of parameters
KR	matrix of investment expenditure for 69/43 industries and 61 regions
YR	matrix of gross industry output for 69/43 industries and 61 regions
PYR	matrix of industry output price for 69/43 industries and 61 regions
PKR	matrix of industry investment price for 69/43 industries and 61 regions
PQRM	matrix of import prices for 69/43 industries and 61 regions
PRSC	vector of consumer price deflator for 61 regions
YRLC	matrix of wage costs (including social security contributions) for 69/43 industries and 61 regions, local currency at current prices
YREE	matrix of employees for 69/43 industries and 61 regions
RLR	is a vector of long-run nominal interest rates for 61 regions
YYN	is a matrix of the ratio of gross output to normal output, for 69/43 industries and 61 regions

Employment equation

Co-integrating long-term equation:

LN(YRE)= BYRE + BYRE * LN(YR) + BYRE * LN(LYLC) + BYRE * LN(YRH) + BYRE * LN(PQRM) + BYRE * LN(YKNO) + BYRE * LN(YCAP) + ECM

Dynamic equation:

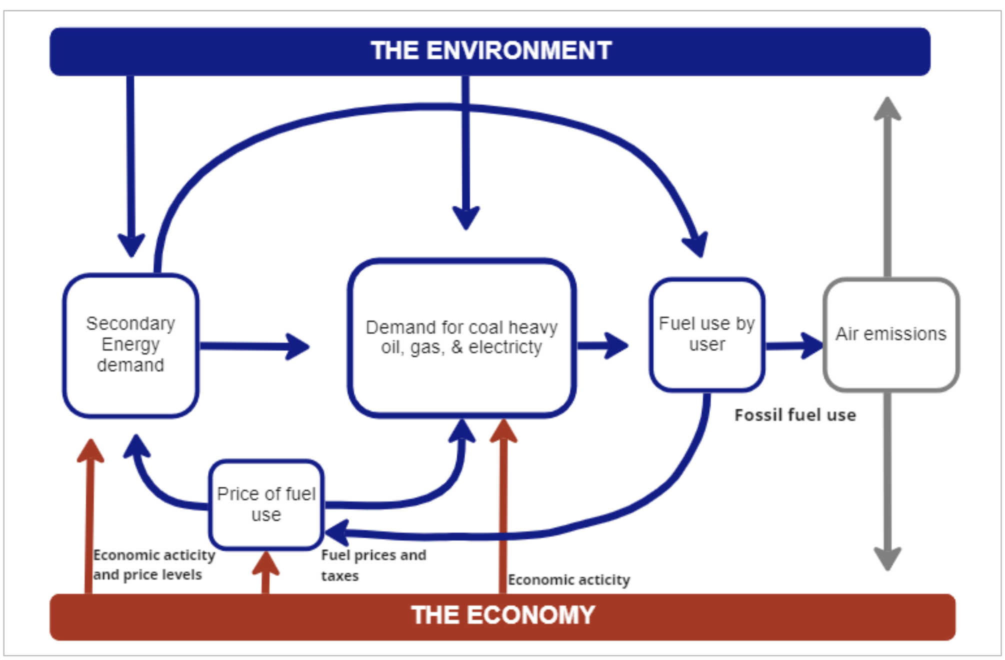
DLN(YRE) = BYRE + BYRE * DLN(YR) + BYRE * DLN(LYLC) + BYRE * DLN(YRH) + BYRE * DLN(PQRM) + BYRE * DLN(YKNO) + BYRE * DLN(YCAP) + BYRE * DLN(YRE)(-1) + BYRE * ECM(-1)

Identity:

LYLC = (YRLC/PYR) / YREE

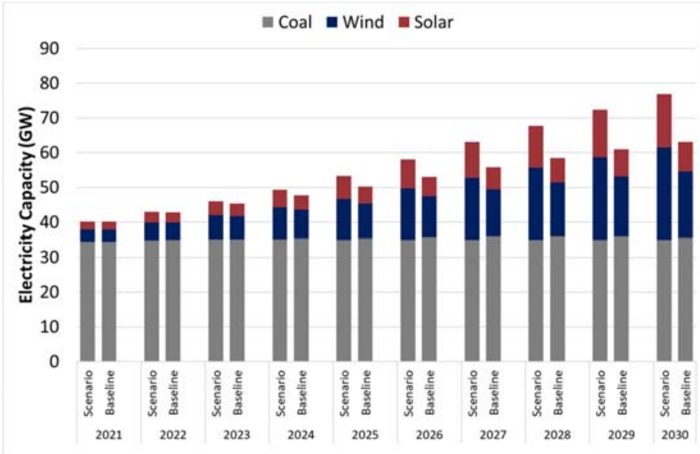
BYRE	is a matrix of parameters
YRE	matrix of total employment for 69/43 industries and 61 regions
YR	matrix of gross industry output for 69/43 industries and 61 regions
YRH	matrix of average hours worked per week for 69/43 industries and 61 regions
YRLC	matrix of employer labour costs (wages plus imputed social security contributions) for 69/43 industries and 61 regions
YKNO	matrix of the knowledge stock for 69/43 industries and 61 regions
YCAP	matrix of the capital stock for 69/43 industries and 61 regions
PYR	matrix of industry output prices for 69/43 industries and 61 regions
YREE	is a matrix of wage and salary earners for 61 regions
PQRM	is a matrix of import prices for 69/43 industries and 61 regions

Figure A1: E3ME's energy model and inputs into the module



Source: Cambridge Econometrics manual (2019)

Figure A2: Baseline and scenario electricity capacity (GW)



Source: E3ME