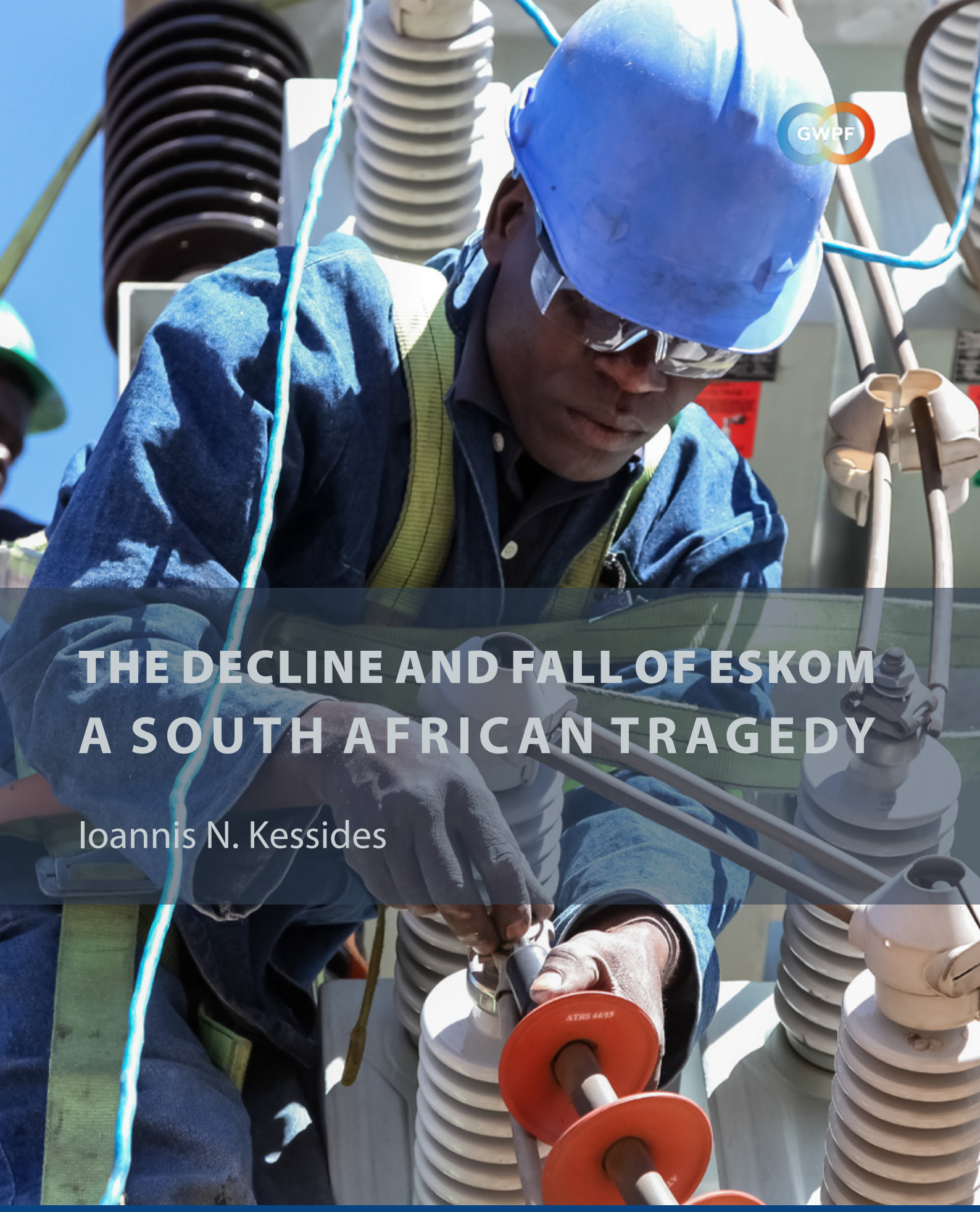

THE DECLINE AND FALL OF ESKOM
A SOUTH AFRICAN TRAGEDY

Ioannis N. Kessides

The Global Warming Policy Foundation
Report 45

The Decline and Fall of Eksom: A South African Tragedy

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About the author

Ioannis Kessides' areas of specialization are energy policy, competition, regulation, and privatisation policies in network utilities, market structure and firm conduct, determinants of entry and exit, and contestability analysis. During 2013–17, he taught energy and infrastructure policy at Yale University, and until July 2013, he was a lead economist in the Development Research Group at the World Bank. He also taught a course on public policy towards business at the Woodrow Wilson School at Princeton. He holds a BS degree (with honors) in physics from Caltech, and both an MA in plasma physics (nuclear fusion) and a PhD in economics from Princeton University. The views expressed in this paper are the author's own and do not reflect those of any of the institutions with which the author has been affiliated in the past, or those of their officers and boards of directors.

Executive summary

Since the end of apartheid and until early 2000, South Africa's state-owned electricity utility, Eskom, was an efficient and well-functioning company even when judged by advanced industrial country standards. Eskom was generating some of the lowest-priced electricity in the world, yet it managed to meet, and in some years actually exceed, the government's ambitious electrification targets with significant cost-reducing innovations. At the same time, it exhibited robust financial and operational performance, was self-financed and, unlike most other state-owned utilities, was not draining the state budget.

Although Eskom was once ranked as one of the world's best-run utilities and was considered the crown jewel of South Africa's state-owned enterprises, during the past two decades it has turned into a classic basket case. After having been saddled with surplus capacity for many years, since early 2000 Eskom has been confronted with escalating plant breakdowns and critically tight reserve margins, to the extent that the adequacy and reliability of its electricity supply have been in jeopardy. The troubled utility has struggled to meet demand, resulting in South Africa's numerous bouts of crippling blackouts between 2007 and 2020. Eskom has also been struggling to service its massive debt – over 440 billion rand ($30 billion) as of October 2019 – which it ran up due to surging primary energy costs, more onerous debt-servicing obligations, increasing labour costs, and especially gross mismanagement and corruption. Today, it is dependent on state bailouts and is effectively bankrupt.

This report seeks to identify the root causes of Eskom's substantially deteriorating performance and South Africa's consequent electricity crisis. It notes that the crisis did not appear suddenly. The first alarm bells sounded publicly over 20 years ago. Nor was it an outcome of circumstances beyond control. It has been a function of a complex set of factors and a direct consequence of misguided public policies, damaging government political interference and malfeasance, and gross corporate governance failure and transgressions. The report focuses on three areas where significant problems have emerged with dire consequences for electricity sector performance:

- *Indecision and paralysis in government policy.* In recent years, government policy towards the electricity sector has been marred by indecision, paralysis, and rigidities. The White Paper released by the Department of Minerals and Energy in 1998 warned of impending electricity shortages and established a number of key priorities, including expanding the system's generating capacity, opening the sector to private investment, allowing competition among suppliers, and diversifying the energy supply. Faced with no imminent crisis the government dragged its feet and took no significant action. The potentially transformative policies advocated by the White Paper were never imple-

mented.

- *State capture, governance failure and corruption*. In recent years, there have been widespread allegations of state capture, corruption and poor management at Eskom, compromising its ability to deliver its mandate. Many of Eskom's governance structures and procedures were incapacitated, corrupted, or otherwise undermined over time. The clearest expression of this corruption has been financial maladministration and a series of questionable and irregular procurement decisions and practices, together with the burgeoning costs associated with the utility's capital expenditure programme and operational expenses.
- *Artificially low prices, underinvestment, and lack of proper maintenance*. For many years, electricity prices in South Africa remained well below cost-reflective levels, thus causing substantial misallocation of resources. These prices did not provide the needed signals and incentives for efficient actions by consumers, suppliers of complementary and substitute services, and investors. Tariffs below the cost of supply meant that Eskom was chronically short of revenue, and thus unable to finance maintenance and new investment from internally generated funds. Delays in critical maintenance caused a significant deterioration in plant performance, with frequent equipment failures, breakdowns, and a consequent decline in plant availability. Moreover, revenue inadequacy in recent years forced Eskom to seek government support. Such dependence on government bailouts inevitably led to increased lack of autonomy and government interference in its day-to-day affairs, and thus to a further loss of efficiency.

This report also outlines the key elements of a potential policy response to address the power crisis in South Africa and meet the energy requirements of the economy. Its central thesis is that the case for radical electricity restructuring and privatisation in South Africa now seems to be inescapable. The government's recently announced decision to unbundle Eskom was clearly a step in the right direction. However, given the magnitude of the country's electricity crisis and the extent to which Eskom has been plagued by mismanagement and corruption, it is the view of this report that the government's divisionalisation plan – calling for the creation of subsidiary generation, transmission, and distribution divisions (to be run by existing Eskom management), rather than full legal and structural separation– falls far short of what needs to be done. It is unlikely that this plan will sufficiently unsettle Eskom's embedded business culture and entrenched management.

The experience of the past couple of decades demonstrates quite clearly South Africa's extreme difficulty in insulating public enterprises like Eskom from the damaging consequences of political interference. This experience has also highlighted the haphazard relationship between political agendas and economically efficient performance in critical sectors of the

economy. The politicisation of Eskom's business resulted in a poorly managed company, with political rather than economic decisions triggering investment, procurement, and the pricing of many important services. Eskom's substantially deteriorating performance, near bankruptcy, and its attendant problems of extreme governance failure and corruption should raise serious doubts about the efficacy of continued public ownership.

In view of this experience, there can be no credible government commitment or promise to wall-off the utility from political management and interference in the future. Government would find it costly to induce a privately-held (albeit regulated) Eskom to act against its profit interest to help some political agenda. Therefore, privatisation might be the only realistic option to insulate the electricity sector from damaging and corrupting political interference, and thus for resolving the sector's unprecedented structural, operational, and financial challenges.

In recent years, there has also been an alarming deterioration in the condition of South Africa's municipal distribution assets. High levels of non-payment for electricity, the municipalities' traditional dependence on electricity revenue to fund other public services, and a lack of appropriate technical resources and governance failure at the municipal level have been important contributing factors. It is the position of this report that an effective way to start and sustain revenue collection discipline, as well as to introduce pricing and other reforms critical to the viability of electricity distribution, is to separate the distribution monopoly segment (both the distribution assets under municipal ownership and those controlled by Eskom) from the rest of the industry, reorganise it so as to correct the current excessive fragmentation, privatise it, and subject it to price or revenue-cap regulation.

The report acknowledges that the unique economic characteristics of the electricity industry – especially the need for coordination between generation and transmission, and the difficulty of replicating vertical relationships with market mechanisms – give Eskom's vertically integrated structure some appeal. At least in theory, it allows it to exploit important investment interrelationships between generation and transmission and to undertake investments based on system-wide planning. However, these benefits are likely be small relative to those that come from promoting competition in generation: lower construction and operating costs, incentives to close inefficient plants, and better pricing. Moreover, the report notes that recent technological advances have dramatically altered the cost structure of electricity generation, allowing efficient operation at more modest scale. These developments, together with the size of the electricity market in South Africa, imply that extensive competition in generation should now be possible. Therefore, all statutory restrictions on entry and ownership in the generation segment should be eliminated.

1. Introduction and preliminary observations

In this paper we analyse the structure, conduct and performance of South Africa's electricity sector and seek to identify public policies that will improve its performance. Our focus on the electricity sector is motivated by its pivotal role in South Africa's economic and social development, a function not only of its significant share in total national product but also of its great influence on the growth and competitiveness of the country's economy as a whole. With its abundance of coal reserves, South Africa used to have a distinct comparative advantage in energy supply, which contributed to growth opportunities, especially in the industrial, manufacturing and mining sectors.

After the end of apartheid and until early 2000, the sector's main operating entity, Eskom, was efficient and well-functioning, even when judged by advanced industrial country standards:

- It was generating some of the lowest-priced electricity in the world; in 2005, for example, the average electricity tariffs in South Africa for both domestic and industrial customers were the lowest among the countries surveyed by the International Energy Agency.
- It managed to meet, and in some years actually exceed, the government's ambitious electrification targets. Within a decade (starting in the early 1990s), the number of domestic electricity customers more than doubled, making South Africa's recorded electrification rates the highest in world.[1] At the same time, dramatic reductions in the capital investment costs of rural connections were achieved through careful network planning and significant technological innovation; between 1995 and 2001, the average cost of rural electrification declined by 40% in real terms.
- It exhibited robust financial and operational performance. It was entirely self-financed through internal reserves and debt raised on the domestic and international capital markets without explicit government guarantees. Thus, unlike most other state-owned utilities, it was not draining the state budget.

During the past decade and a half, South Africa has been facing an unprecedented electricity crisis, due to a persistent and widening gap between demand and available generating capacity. After having been saddled with surplus capacity for over two decades (due to overinvest-

ment from the late 1970s to the early 1990s), in recent years the demand/supply balance has been very tight, and system reliability has been in jeopardy. This is evidenced by the decline in the system's reserve margin, from nearly 40% in 1992 to an alarmingly low level of 5.1% in 2007. This is considerably less than the 15% figure typical of a well-run electricity system, a level that is important because it allows for preventive maintenance, particularly mid-life refurbishments, and unplanned shut-downs. There has been recurring and crippling load-shedding in several areas of the country.

Up until early 2000, Eskom was regarded as the crown jewel of South Africa's state-owned enterprises and one of the leading power companies in the world.[2] Today it is facing severe corporate governance problems, is in a precarious financial condition and is reliant on state bailouts. Incredibly, it is now considered to be the biggest risk to the country's economy. It is unable to cover its costs and is saddled with a massive debt, a bloated organisational structure, and an imploding infrastructure. Its ageing and poorly maintained plants have been exhibiting declining technical performance and are struggling to meet demand. Moreover, in recent years, Eskom has undergone repeated board and management changes, getting through ten chief executive officers in a decade.[3] When Moody's Investors Service and Standard & Poor's cut the utility's rating to non-investment grade in November 2014 and March 2015 respectively, governance failure was cited as a key reason. In recent years, Eskom has been also rocked by allegations of widespread corruption and gross mismanagement. In fact, several international companies have been caught up in Eskom-related graft allegations.

Load-shedding is causing significant disruption of civic and economic life. For South Africa's industrial, manufacturing, mining, commercial, and agricultural users, the costs of the upsurge in power shortages have been enormous. Electricity shortages are now a powerful constraint on South Africa's fragile economic recovery, and may ultimately undermine the credibility and legitimacy of government and threaten to further stress the social fabric of the country. Thus the consequences of Eskom's load-shedding have become a major political issue, reflecting the hardships they cause for individuals and their crippling effects on the economy. By some estimates, load-shedding has cost South Africa's economy an extraordinary R1.4 trillion over the past decade – a tumultuous period during which the country struggled with alarmingly slow GDP growth.[4]

Once ranked as one of the world's best-run utilities, during the past twenty or so years Eskom has turned into a classic basket case. Why did this happen? This paper seeks to identify the root causes of the crisis and outlines the key elements of a potential policy response; one that will address the utility's and the sector's structural, operational, and financial challenges.

2. The structure of the electricity industry in South Africa

Two characteristics of South Africa's electricity supply industry – the virtual monopoly of the state-owned, vertically integrated utility, Eskom, and the extreme dominance of coal-fired plants in generation – have profound implications for market behaviour, the magnitude of negative environmental externalities, and industry performance.

Vertical and horizontal dominance of Eskom

Eskom is an energy giant even by international standards. It accounts for 40% of the electricity generated in the entire African continent. In 2017, it ranked 17th in the world in terms of installed generating capacity – its 46 GW coming just below India's NTPC (54 GW), the USA's Duke Energy (52 GW) and Spain's Iberdrola (48 GW).[5] And it ranked 9th (in 2016) among the world's generation companies using coal as combustion fuel.[6] In fact, Eskom's Medupi and Kusile power stations, when fully operational, will have installed capacities of over 4764 MW and 4800 MW respectively, making them among the largest coal-fired stations in the world.

Figure 1 shows the vertical and horizontal structure of South Africa's electricity supply industry. Eskom generates, transmits and distributes electricity to industrial, mining, commercial, agricultural and residential customers. It also distributes to municipalities, which in turn redistribute power to households and businesses within their jurisdictions. Eskom purchases electricity from independent power producers under a variety of power purchase agreements, and also from generating facilities beyond the country's borders.

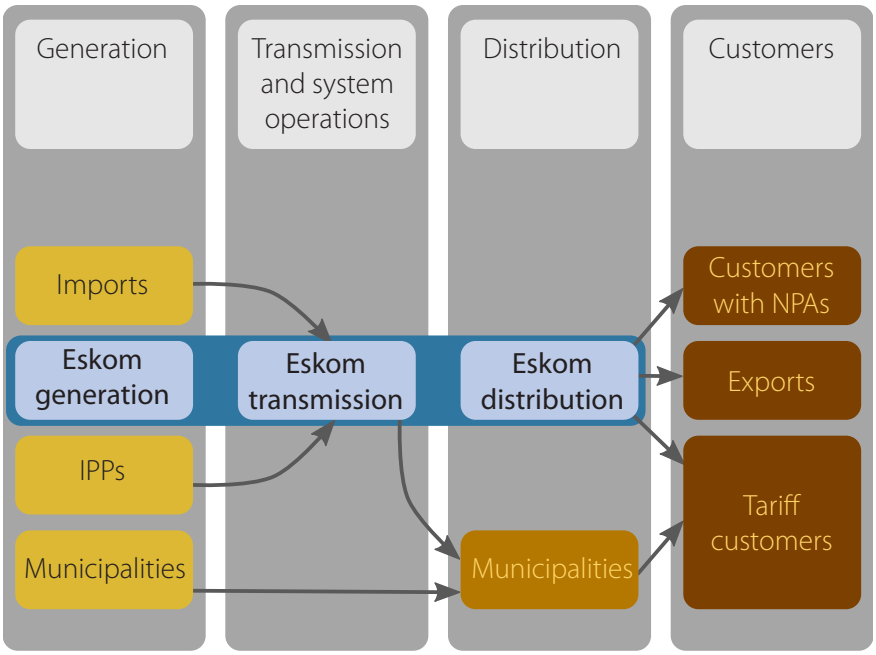


Figure 1: Structure of South Africa's electricity supply industry.

IPP, independent power producer; NPA, negotiating pricing agreement Source: DPE (2019).

Eskom has enjoyed a near monopoly in both generation and transmission since its creation in 1923. In 2004, for example, it accounted for approximately 96% of South Africa's total generated electricity. Today it remains the country's primary electricity supplier, generating more than 90% of the electricity consumed. It also owns, operates and maintains virtually 100% of the national transmission network, comprising approximately 33,000 km of high tension (between 132 to 765 kV) transmission lines, the bulk of which (19,523 km) is at 400 kV. Eskom shares the distribution network with approximately 87 licensed municipal distributors.[7] Although its dominance in distribution is less pronounced, it still supplies about 58% of electricity to final customers, with the remaining 42% provided by municipal authorities.[8] These local authorities buy the majority of their power in bulk from Eskom, although a few also generate small amounts of electricity in their respective areas of jurisdiction. A few large industries have private generation facilities too, producing power for their own use.

Eskom has a generating fleet that is heavily dominated by coal-fired plants[9] (see Figure 2; a detailed breakdown of the fleet can be found in the Appendix).

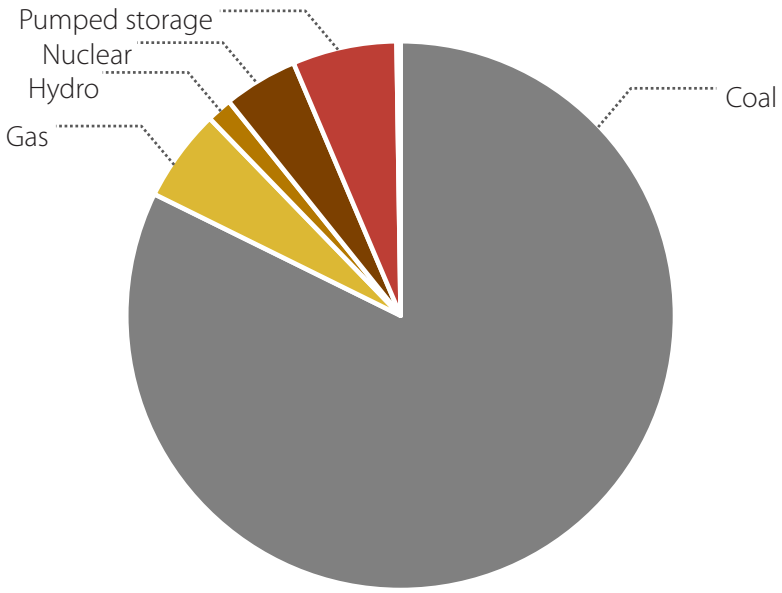


Figure 2: South Africa's generation capacity by type.
Source: Eskom (2019a).

The bulk of Eskom's coal-fired generating capacity is located in the province of Mpumalanga, which produces about 80% of the country's coal.[10] Eskom also operates Africa's only nuclear power station, Koeberg, located near the major load centre of Cape Town, at the opposite end of the country. The Koeberg nuclear power station consists of two units, each with a three-loop Framatome pressurised water reactor (PWR) whose condensers are cooled by seawater. The station boasts the largest turbine generators in the Southern Hemisphere and is considered one of the safest of the world's top-ranking PWRs.

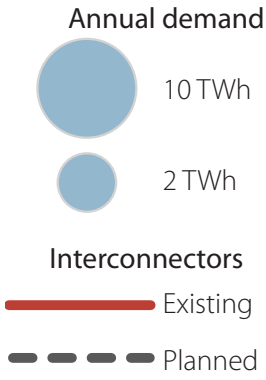
In 2003, due to a sharp increase in the demand for electricity, Eskom decided to refurbish and return to service three coal-fired stations that had been mothballed in the late 1980s and early 1990s.[11] In recent years, its new-build efforts have focused primarily on two massive coal-fired stations.[12]

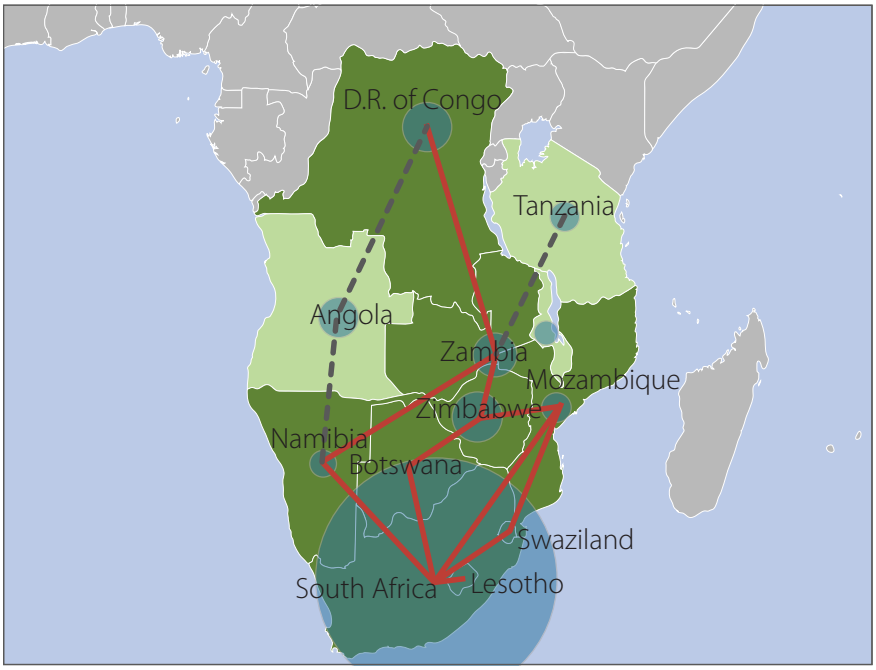
South Africa is a generally dry country, with erratic rainfall, and thus water resources are at a premium. Eskom's two units on the Orange River are the only conventional hydroelectric schemes of any significance in the country. There are also three pumped storage schemes,[13] which play a critical role in meeting peak demand, system balancing and control. Eskom's peaking generation capacity also includes two identical gas turbine stations,[14] each operating three closed-cycle generators, and two more equipped with open-cycle gas turbine technology.[15]

South Africa is an integral part of the Southern Africa Power Pool (SAPP; see Figure 3). Eskom imports electricity from Lesotho, Mozambique, Zambia and Zimbabwe, and exports to Botswana, Swaziland, Lesotho, Mozambique, Namibia, Zambia and Zimbabwe. Total imports were 9,703 GWh in 2015/2016, with exports of 13,465 GWh (about 6% of the total produced by Eskom stations) in the same period. South Africa is by far the largest market in the SAPP, accounting for approximately 90% of the pool's total quantity of electricity demanded; moreover, in 2016, the country accounted for 85% of the SAPP's total electricity traded.[16] The importance of these electricity trading relationships is highlighted by the agreements between Eskom and Zambia. In 1998, Eskom signed an agreement with the Zambia Electricity Supply Corporation that allowed South Africa to import Zambia's excess power – 300 MW during peak power generation periods.[17] By 2019, Zambia faced a power deficit of 700 MW, due to reduced generation in its hydro power plants caused by poor rains. This deficit caused up to 15-hour load shedding in some of Zambia's communities. In late

Figure 3: Southern Africa Power Pool

Source: Wright and van Coller (2018).



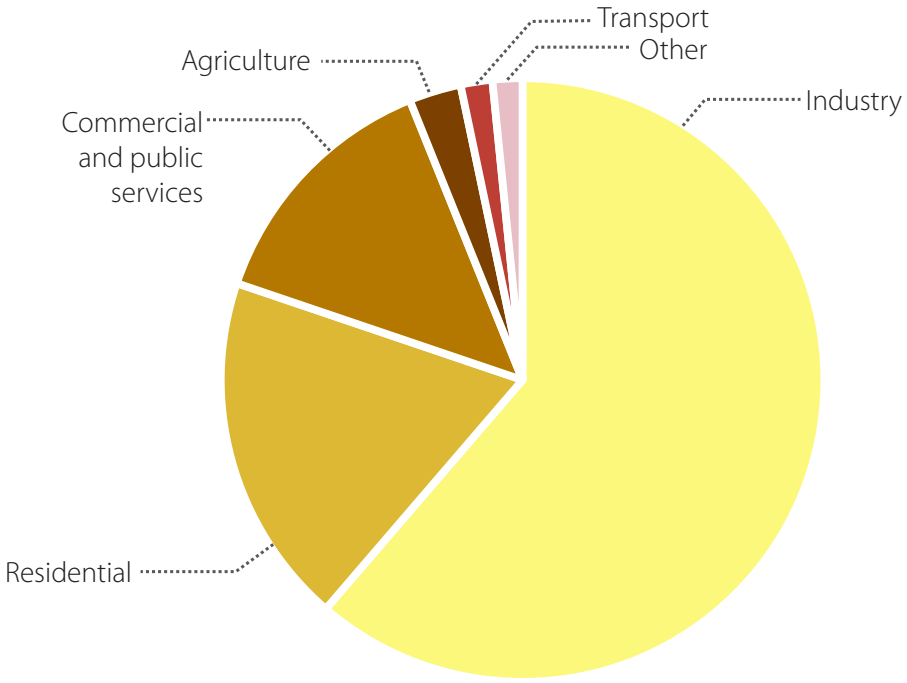


2019, Eskom, which has been facing its own capacity constraints and is cash strapped, agreed to supply 300 MW to Zambia to ease the country's severe power deficit.[18]

Eskom operated an internal pool market for a number of years. The primary objective of the Eskom Power Pool was to facilitate optimal dispatch by providing a competitive trading platform where prices are determined by the competitive bidding of participating generators.[19] However, the extent to which the pool could lead to a competitive market was limited by the fact that all the participating generators were Eskom power stations.[20] Plans to construct a 100 MW concentrating solar power plant near Upington in the Northern Cape were scraped in 2018 because the project was deemed too expensive. Eskom sells power to over 800 municipal distributors, 2,700 industrial, 980 mining, 52,500 commercial, 6.3 million residential, and 81,300 agricultural customers. In 2018/19 municipal distributors accounted for nearly half of Eskom's electricity sales[21].

Mining and manufacturing account for just over 60% of South Africa's total electricity consumption (Figure 4).[22] This has important implications for the overall trend in electricity demand in South Africa and also the impacts of load-shedding. The mining and manufacturing sectors are key drivers of the economy and their efficient functioning is dependent on large volumes of firm, uninterruptible baseload electricity. This fact explains Eskom's pivotal role in South Africa's economy and the crippling impacts of load-shedding.

Figure 4: Electricity consumption by sector.
Source: Mokveld and von Eije, 2018.

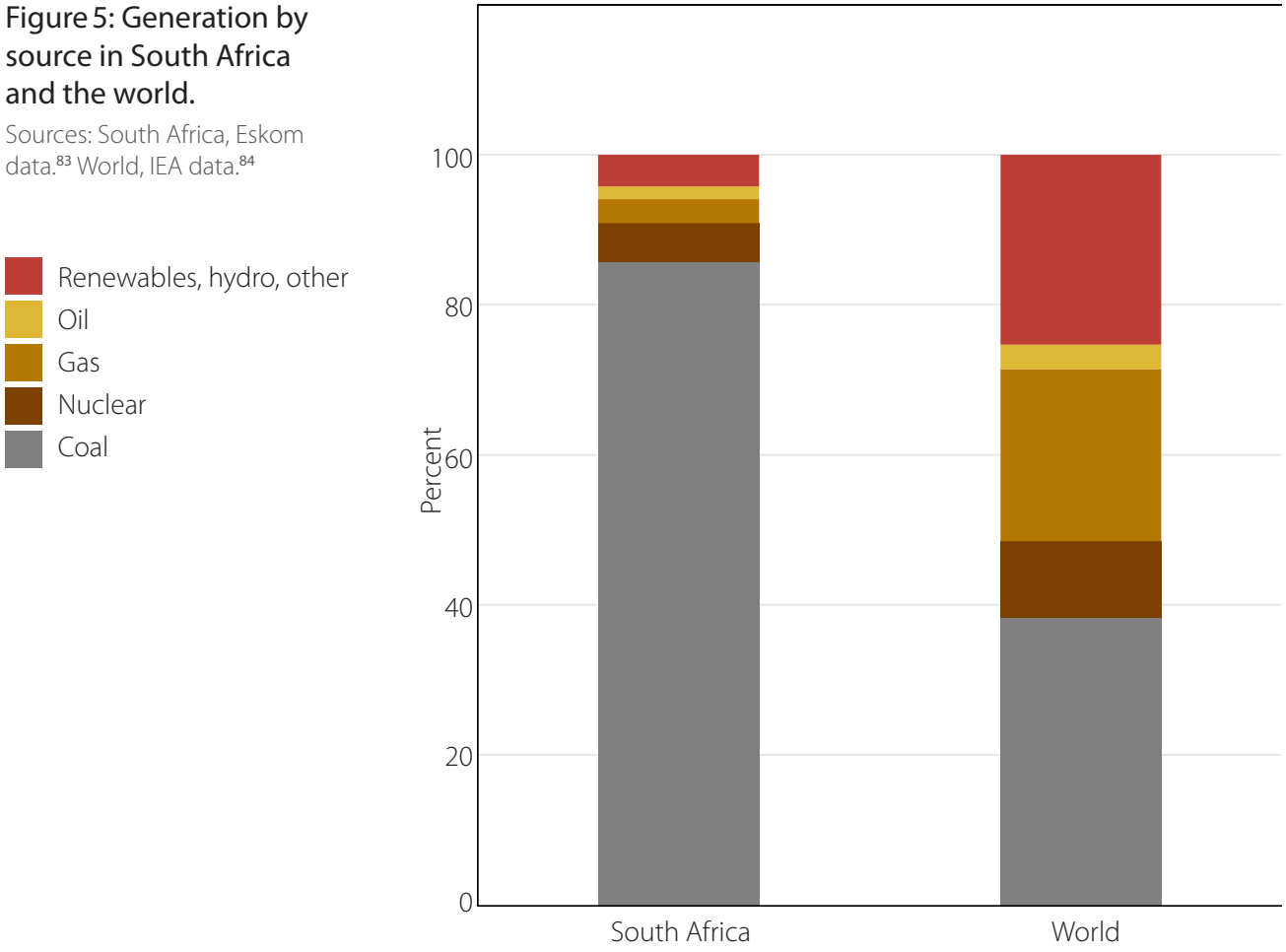


The dominance of coal

South Africa is blessed with abundant coal. The country has the world's 12th largest proven coal reserves – approximately 10 billion tonnes, about 1% of the world total. In 2018, it was the world's seventh largest coal producer and the fourth largest coal consumer.[23] By international standards, its coal deposits are relatively shallow, with thick seams that make them easier and, in general, more economical to mine.[24] At the present production rate, there should be around 40 years of coal supply left.[25] South Africa, on the other hand, has very limited oil and gas deposits. Because of this, its electricity-generation profile looks quite different from that of the rest of the world (Figure 5).

Figure 5: Generation by source in South Africa and the world.

Sources: South Africa, Eskom data.[83] World, IEA data.[84]



South Africa's unique primary resource endowment had profound implications for the structure of its economy. Historically, coal was cheap, and cheap energy facilitated the development of mineral-extractive and energy-intensive industries, such as mining, basic iron and steel, basic non-ferrous metals, petrochemicals, chemicals and man-made fibres, paper and related products. These industries still remain at the heart of South Africa's industrial trajectory and exports. Thus, coal has played a very important role in South Africa becoming the most advanced economy in Africa, but this economic path has tended to limit the possible scenarios for further development.

3. Eskom's historical performance

For much of the time between the late 1970s and the early 2000s, South Africa has had low and declining (in real terms) electricity prices. During the same period, Eskom:

- exhibited robust financial performance and earned a solid rate of return on its assets;
- reduced its debt/equity ratio, reaching a record low by 2005, when Moody's upgraded the utility's domestic currency debt to A1 and foreign currency debt to A2, thus laying the ground for access to cheaper capital;[26]
- implemented an accelerated electrification program (doubling within a decade the number of domestic electricity customers) with internally generated funds raised through internal cross-subsidies and a surcharge on electricity sales, as well as through debt financing;
- improved its generation plant performance, with several of its technical performance metrics reaching world-class levels.

Pricing and investment behaviour

Historically, South Africa has had low electricity prices, in part due to its abundant and easy-to-mine coal deposits. Until recently, Eskom procured the bulk of its coal from captive collieries or under medium-term supply contracts, at prices that on average were much lower than the corresponding export prices. This was because exports were constrained by significant bottlenecks in transportation facilities, particularly in the rail and ports sectors, which were dominated by another state-owned enterprise, Transnet. In 2008, for example, the average purchase price for domestic bituminous coal was R150 per tonne, only one fifth of the export price of R739 per tonne.[27] During that period, European coal prices, even at their lowest, were nearly three times the price paid by Eskom.[28]

While prices have been driven by access to abundant and cheap coal, they have also been influenced by the government's changing policy and political priorities and its determination to redress the social and economic inequities that remained after decades of apartheid policies. Thus several important elements of political economy have been at play.

For over two decades, from the early 1970s to the mid 1990s, Eskom had a sustained and very extensive capacity-expansion program. This was stimulated by the substantial changes in the relative prices of primary energy sources that followed the oil shocks of the 1970s. A state-led drive to flush out as much oil as possible from the economy led to a significant growth in electricity demand, as energy-intensive industries were encouraged to shift from oil to coal-based electricity.[29] Annual growth in peak demand ranged between 6 and 16% between 1972 and 1982.[30] The prospect of potential power shortages led Eskom engineers and planners to start a power-station construction spree. By the end of 1983, 22,260 MW of additional generation capacity had

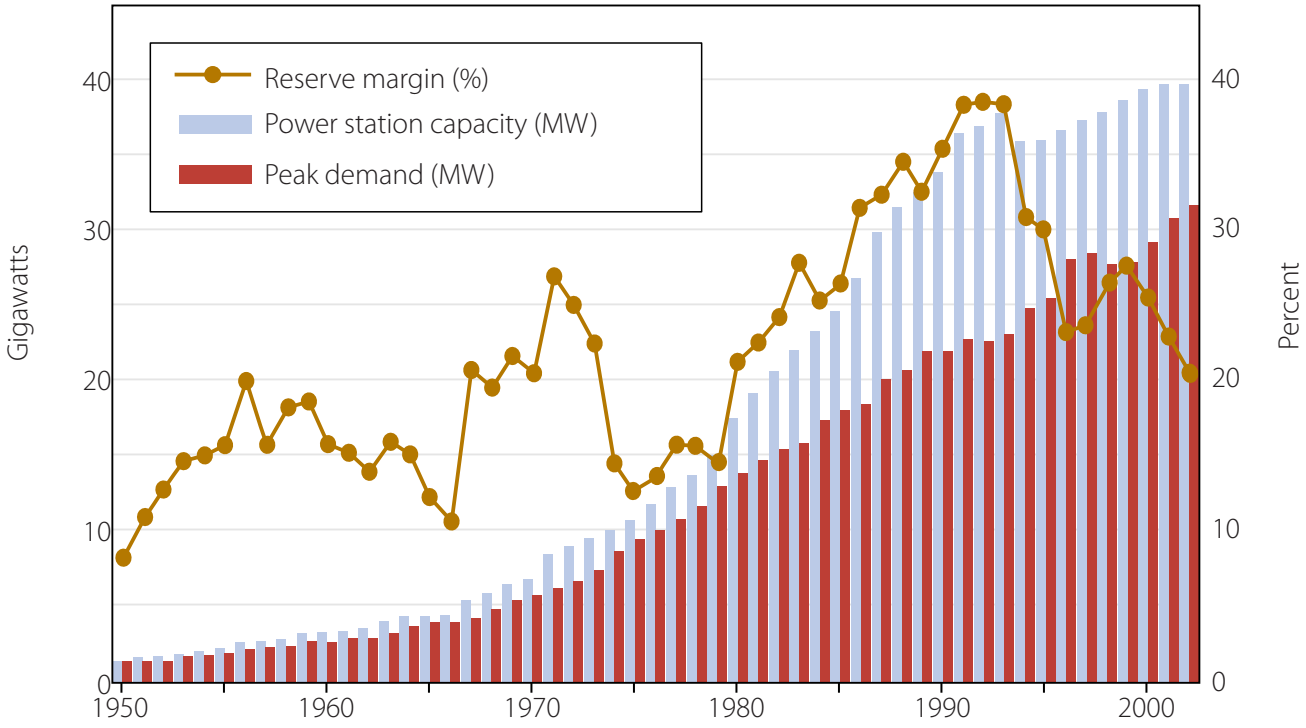
been ordered, double the operating capacity during that year.[31] The growth in capacity was especially striking between 1974 and 1993 (Figure 6).

As a result, from the mid-1980s Eskom had a sizeable surplus in generating capacity. It should be noted that overcapacity is not an uncommon situation. It is a fundamental design attribute of electricity markets, in both the franchise monopoly and the liberalised market eras, to maintain extra generating capacity, generally by requiring electric utilities to have capacity reserves at a level typically around 15% above the forecast, coincident, non-interruptible demand peak. Also, it is widely accepted that the social cost of overinvestment (higher electricity cost) is small relative to the social cost of underinvestment – shortages and blackouts can have hugely disruptive effects, with severe economic and social consequences. Thus, if some deviation from the optimum level of capacity is inevitable, society should err on the side of overinvestment.

Sub-optimal use of generation capital is therefore not unique to Eskom. State-owned utilities in particular, have historically had difficulty making investment decisions regarding new generation capacity.[32] However, Eskom's capacity expansion was excessive relative to demand; from 1980 to 2000, its reserve margin rates far exceeded those dictated by reliability and adequacy considerations. In the early 1990s, they fluctuated just below 40%. The presence of excess capacity, far above the normal 15% reserve margin, for such a long time clearly signifies gross inefficiency in investment. It also raises serious questions about the sector's governance structure and the manner in which decisions were made.

Figure 6: Growth in Eskom's net capacity and peak demand.

Source: Eberhard (2004).



Eskom financed its capacity expansion program by raising debt through the domestic bond market and through the issuance of US Dollar denominated bonds in the international debt markets. In the face of increasing capital shortages in South Africa, the country's Electricity Act was amended in 1971 to allow Eskom to build up its capital reserves through greater retained earnings. Real electricity prices rose sharply in the late 1970s and then again in the early 1980s (Figure 7). This second round of price increases led to a public outcry and ultimately to the establishment of the De Villiers Commission of Inquiry into Eskom's activities. The commission was critical of the utility's governance and management structures, electricity forecasting methods, investment decisions and accounting.[33] In particular, it concluded that Eskom's investment planning was highly defective and that the utility substantially overinvested in generating capacity.

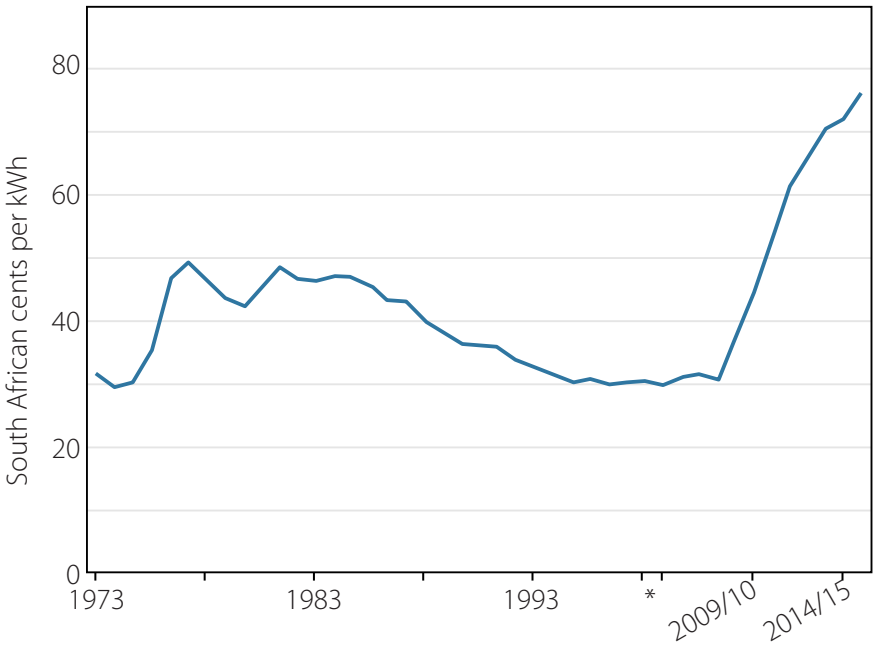


Figure 7: Trend in average electricity prices, 1973–2015/16.

*After 2003, the year end changed. Prices are given in real (2016) terms.
Source: Deloitte (2017).

Except for a brief period from 1980–83, during the three decades between 1978 and 2008 electricity prices in South Africa steadily declined to artificially low levels (Figure 7). The real average price of electricity declined by approximately 40%, from the already low level of 49.5 c/kWh (in 2016 rands) in 1978 to 30.1 c/kWh in 2004/5,[34] a much faster decline than the OECD average and in contrast to other middle-income countries like Mexico and Turkey.[35]

In summary, there are several factors that contributed to the low and declining electricity prices in South Africa:

- the low domestic price of coal and the location of the coal-fired generation stations near the mines;
- excess capacity, which Eskom tried to market to large industrial, manufacturing, and mining users on special price terms;

- the ability of municipal distributors and large industrial and mining customers – a large portion of Eskom's sales – to negotiate favourable rates;
- Eskom's exemption from paying dividends to shareholders or tax to government, and thus not having to bear the full opportunity cost of debt finance – the government guaranteed Eskom's bonds and the South African Reserve Bank provided forward cover at preferential rates;
- declining debt and financing costs, as Eskom enjoyed a period in which its investment requirements were small, following the overinvestment in the late 1970s and early 1980s;
- environmental externalities associated with coal-fired generation remaining outside the pricing mechanism.

Financial performance

Eskom exhibited social leadership without sacrificing financial performance. While it was providing some of the cheapest electricity in the world, during this period the utility maintained a very robust financial performance. In contrast to most other state-owned electric utilities, it was entirely self-financed, through internal reserves and debt raised on the capital markets. And it consistently achieved financial viability – revenues were adequate to cover its pertinent costs, including operating expenses, capital charges, and a return on equity. For example, during 1995–2005, it earned a pre-tax rate of return on its assets of between 8 and 12% (Figure 8). In 2004/05 it posted a record net profit. Performance was driven by strong sales volumes, which were boosted by robust demand from mining companies enjoying high commodity prices, and buoyant economic growth. Eskom's robust financial performance led to investment-grade ratings from Standard & Poor's, Moody's, and Fitch, an achievement few state-owned utilities in developing countries could match at that time.[36]

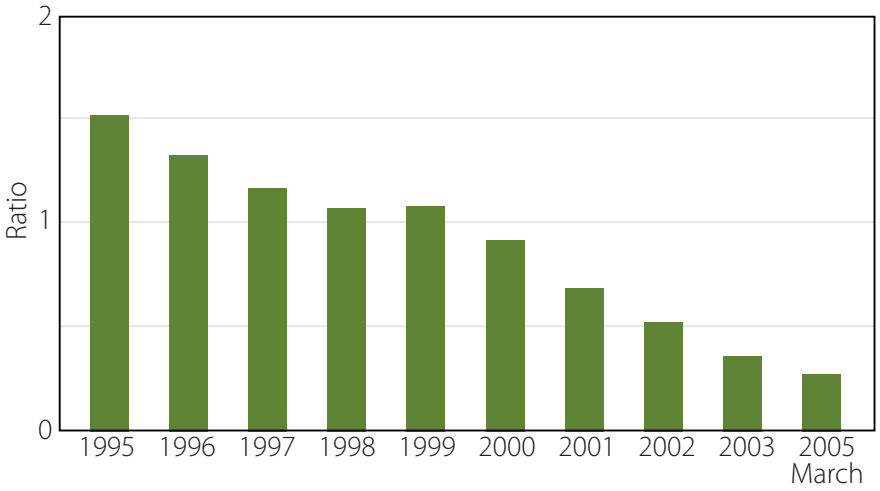
Figure 8: Eskom rate of return on total assets.

*15 months. Source: Eskom, 2005. Annual Report.

The strengthening of Eskom's balance sheet is further evidenced by its debt/equity ratio, which declined from 2.06 in 1980 to 1.5 in 1995, and 0.3 in December 2003. It improved further to a new record low of 0.18 in March 2005 (Figure 9).

Figure 9: Eskom debt/equity ratio, including long-term provisions.

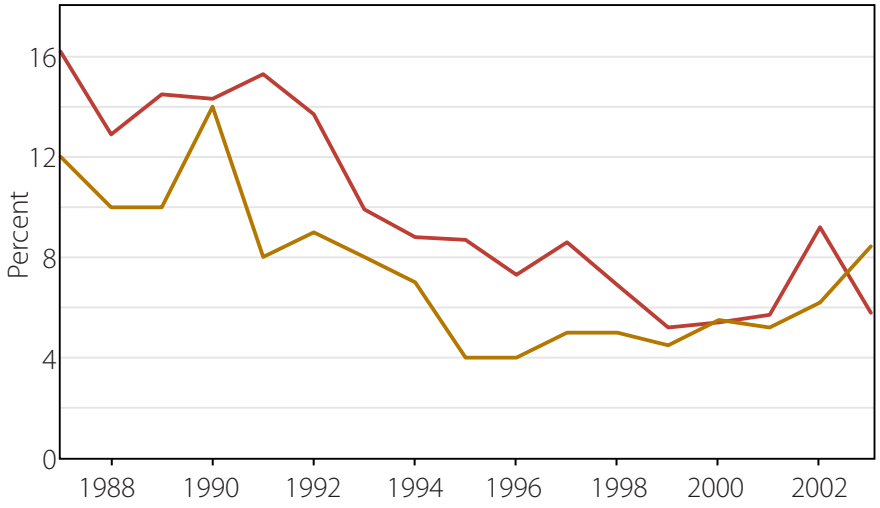
Source: Eskom, 2005. Annual Report. There was a change in year end in 2005.



It is important to note that this exceptional improvement in Eskom's financial performance was brought about while the utility reduced its prices in real terms. Indeed, from the late 1980s, its average tariff increases were consistently below inflation, until the trend reversed in 2003 (Figure 10).

Figure 10: Eskom average tariff increase compared to Consumer Price Index, 1987–2003.

Source: van Heerden et al. (2005).



4. Quality and reliability of supply

In the late 1980s, Eskom experienced significant deterioration in the performance of its generation plants. There was a high incidence of costly plant damage and unit trips, to the extent that by 1989 its unplanned capability loss factor (UCLF) – the percentage of maximum energy generation that a plant is not capable of supplying to the electrical grid because of unplanned energy losses, such as unplanned shutdowns, outage extensions or load reductions[37] – reached the unacceptably high rate of 14% (Figure 11).[38]

Similarly, during the same year, its unit capability factor (UCF)

Figure 11: Eskom's unplanned capability loss factor.

Source: Eskom annual reports.

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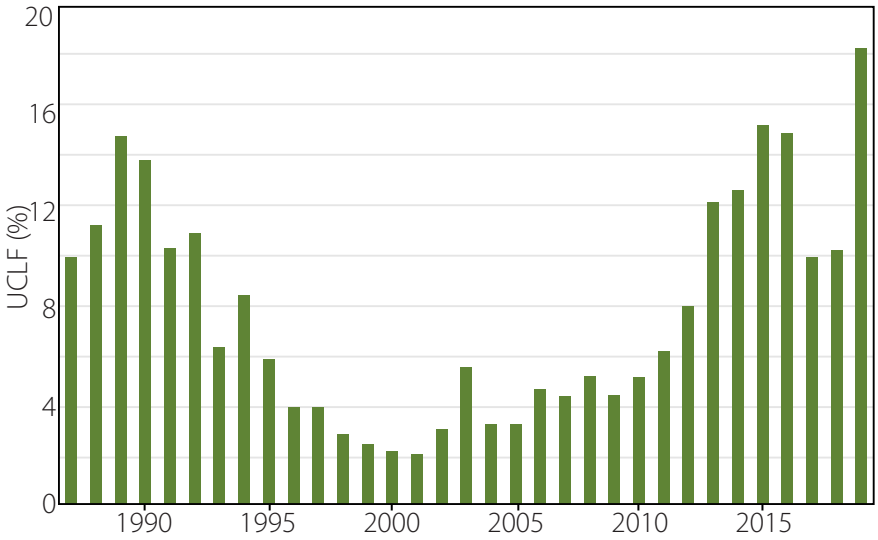
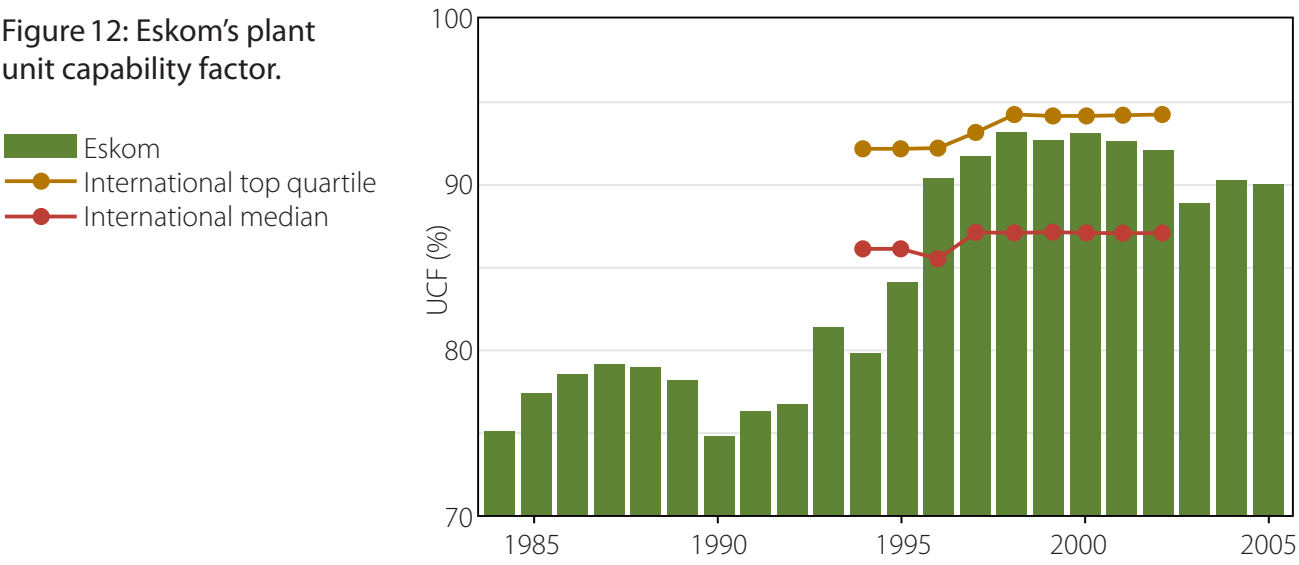


– the percentage of maximum energy generation that a plant is capable of supplying to the electrical grid, limited only by factors within the control of plant management[39] – stood only just above 78%, and by 1990 it had declined further, to around 75% (Figure 12).[40] These low plant availability rates were due to frequent breakdowns requiring enhanced maintenance.

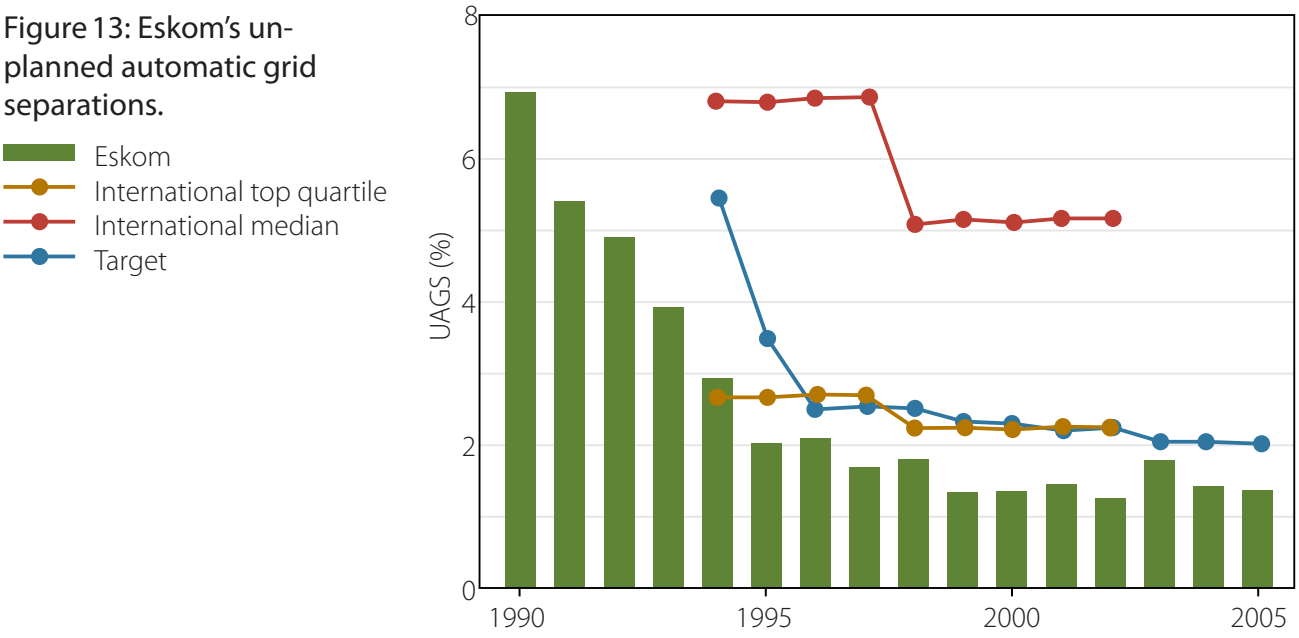
Figure 12: Eskom's plant unit capability factor.



In 1990, Eskom's generating units experienced, on average, seven unplanned automatic grid separations (UAGS), more than double the international best quartile, which was below three (Figure 13). This indicated a large number of supply interruptions per operating period (7000 hours) and hence a low reliability of service provided to the electrical grid.[41]

In response to the deterioration in plant performance, Eskom undertook a series of actions and supply-side management initiatives. Key among these was a programme to improve plant availa-

Figure 13: Eskom's unplanned automatic grid separations.



bility, which became known as '90:7:3'. The goals of the programme were to:

- make the system's representative plant available to supply power on average 90% of the time (UCF);
- limit planned plant shutdowns for maintenance to 7% of the time (planned capability loss factor);
- restrict plant breakdowns and other unforeseen outages to 3% of the time (UCLF).

The '90:7:3' initiative led to significant improvements in Eskom's plant performance. UCLF declined from the unacceptably high rate of 14% in 1988 to 3.6% at the end of 1997. By 2002 it was further reduced to a world-class rate of 3% (Figure 11). Similar improvements were obtained in plant availability by reducing planned and unplanned outages. By 1998, Eskom's power stations reached an average generating-unit UCF of 93%, and remained above 90% until 2002, just below the international best quartile, but well above the international median rate. There was some deterioration after 2002, and during 2004–2005 the UCF rate fluctuated around 90% (Figure 12). The decline in average generating-unit UCF during 2003 was primarily due to a catastrophic failure of the turbine generator of Unit 2 at Duvha power station. Some of the observed deterioration may also be attributable to deliberate decisions by Eskom to optimise plant availability across its portfolio in favour of low-cost production. Despite these abnormal plant failures, Eskom was still able to meet a significant increase in demand during 2003.[42]

Further evidence that the '90:7:3' initiative led to significant improvements in technical performance and availability is provided by the dramatic decrease in the number of supply interruptions per operating period (7000 hours) that Eskom achieved, especially between 1990 and 2000 (Figure 13). After 1995, its generating units experienced fewer interruptions than even the international best quartile, indicating world-class plant management and maintenance. In 2000, Eskom peaking stations set new records by claiming only 0.58 separations per 7000 hours – well below the international best quartile for that year.

Security of supply

A system's installed generating capacity can be considered adequate when peak demand for electricity is covered by an adequate reserve margin – the difference between the peak load and the portion of electric resources that are expected to be able to operate during the peak load. If planned maintenance can be performed outside the seasonal peak, the reserve margin must allow for forced (unplanned) outages of generating plant – the system's operating reserve must be sufficient to withstand the loss of the largest plant.

As noted above, because of its major capacity expansion in the 1970s and 1980s (when almost half of its current capacity was installed), Eskom had high spare capacity and a more than adequate reserve margin for over 20 years, between 1978 and 2002 (Figure 6). Indeed, during most of those years, the reserve margin exceeded

25% and thus it was well above the 15% minimum (and 20% optimum) target for predominately thermal systems.

Deteriorating performance since early 2000

Until roughly two decades ago, South Africa's electricity system seems to have been well-run and, since the end of apartheid, to have operated in a manner reflecting genuine commitment to the public interest. However, since early 2000, South Africa has been facing an electricity crisis, the depth of which in recent years has been unprecedented even by developing-country standards. During the past decade in particular, the electricity system has had a tight and declining reserve margin, and thus the adequacy of and reliability of the supply have been placed in jeopardy. Demand has frequently exceeded supply, and since 2008 load-shedding has been experienced across the country. Power cuts have become a regular occurrence. Despite the sharp escalation in the price of electricity, Eskom has been operating at a loss, accrued a massive debt load, and has failed to perform the necessary preventive maintenance on its generation, transmission, and distribution assets. Moreover, in an effort to limit power cuts, it has effectively run its ageing and under-maintained generating plants to the ground.

The decay of the utility's assets is manifested in the sharp deterioration of their technical performance metrics, to well below world-class levels. These are considered in the next sections.

Critically tight reserve margins

Following its extensive capacity expansion from the early-1970s to the mid-1990s and the resulting criticism from the De Villiers Commission, for the last 20 years Eskom has built almost no new power stations.[43] However, from the mid-1990s, South Africa saw strong industrial and economic growth, and there was an impressive electrification drive. As a result, between 1994 and 2008, demand for electricity grew by around 50%, leading to a steady decline in the excess of generating capacity. This in turn led to an erosion of the very high reserve margins, from nearly 40% in 1992 to an alarmingly low level of 5.1% in 2007 (Figure 14).

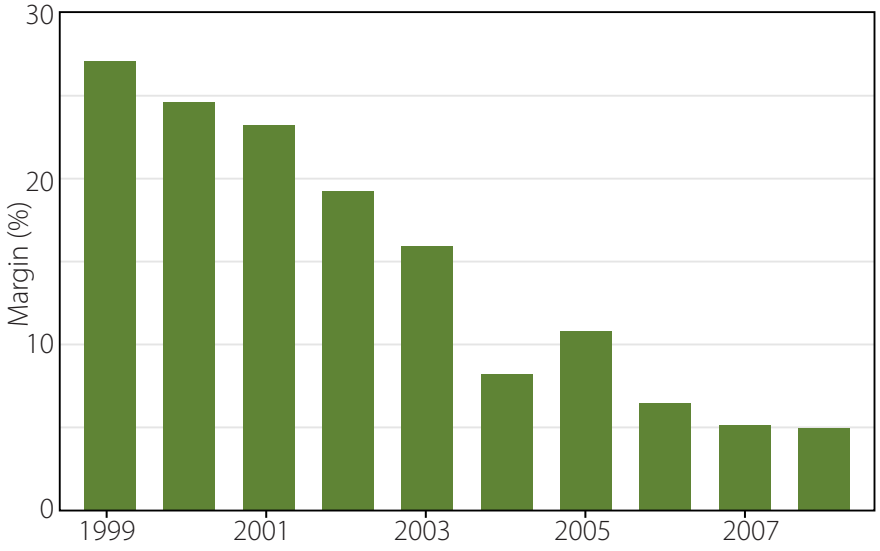


Figure 14: Eskom's reserve margins.
Source: Eskom (2008).

Declining plant availability

Eskom's plant availability, as measured by the energy availability factor (EAF),[44] was consistently above 90% in the late 1990s as a result of a series of actions and supply-side initiatives undertaken by management. EAF was around 92% during 1998–2001, well-above the international median and just below the international best quartile.

After that time, it declined steadily, to a low of 71% in 2016, before recovering to an average of around 77% during 2017–18 due to a rigorous plant maintenance program. However, the improvement was short-lived. EAF regressed to levels below 70% in 2019 (Figure 15). This low level of plant availability was a key factor behind the load-shedding in recent years.[45]

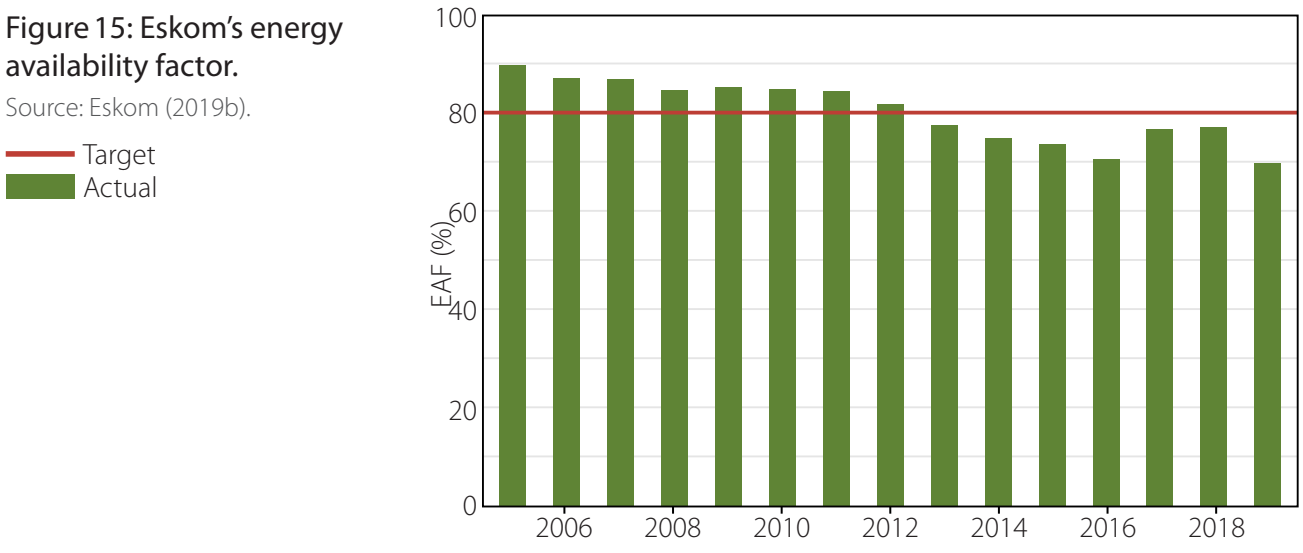
The decline in the EAF can be largely ascribed to the sharp escalation in unplanned production interruptions, resulting from equipment failures and other problems. Plant conditions have steadily deteriorated since early 2000, and breakdowns, as measured by the UCLF, have increased steadily since early 2000, deteriorating very sharply in recent years. After having achieved a world-class low of just over 2% in 2002, UCLF reached the highly destabilising level of 18.3% at the end of March 2019 (Figure 11).

A number of factors contributed to the sharp increase in unplanned maintenance/breakdowns and the concomitant decline in plant reliability. These include:

- running the power stations hard and delaying critical maintenance in order to keep the lights on in the face of increased demand and stagnant generating capacity;
- a large portion (almost two-thirds as of 2014) of Eskom's base load plants being past the middle of their operating lifetimes and thus requiring longer outages;
- declining coal quality, which impacts plant performance, necessitating additional plant maintenance;
- increased irregularity in coal deliveries, which rendered Eskom's inventory management more complex and led to disruptions of fuel supply to power stations.[46]

Figure 15: Eskom's energy availability factor.

Source: Eskom (2019b).



5. The root causes of the crisis

South Africa's electricity crisis did not appear all of a sudden. The first alarm bells sounded over 20 years ago. Nor was it an outcome of circumstances beyond anyone's control. It has been a function of a complex set of factors and circumstances: misguided public policies, government malfeasance, and corporate governance failure. The main areas of concern are:

- indecision and paralysis in government policy
- state capture, governance failure and corruption
- artificially low prices, underinvestment and lack of proper maintenance.

These issues will be considered in the next sections.

Indecision and paralysis in government policy

Long before the crisis hit and the first extensive rolling blackouts began in October 2007, it was clear that new investment in electricity generation would be needed. It takes several years to design and build power stations. Coal-fired plants in particular are complex systems with long lead-times. They are also relatively costly because their construction involves large quantities of expensive materials, such as iron and steel, and requires specialised labour and engineering expertise. Some components of a coal-fired power station, such as its steam turbines, can be assembled in a factory and then delivered to the site, but much of the assembly of the boiler and the flue-gas cleaning systems must take place at the site itself. As a consequence, the cost of a coal-fired power plant will be vulnerable to volatile commodity/material prices (alloy pipes, steel, copper, and concrete) and increasing labour costs. In recent years, cost increases have been driven by worldwide competition for power plant design and construction resources, and equipment and manufacturing capacity. Thus any indecision surrounding the construction of such large-scale complex systems can have important cost implications. Efforts to artificially compress their construction times can lead to costly design and assembly mistakes, very long retrofit delays, and significant increases in the likelihood of operational breakdowns. Similarly, any changes in the technical experts overseeing the design and construction of a power plant can adversely affect build costs and lead-times.

Eskom, like other utilities around the world, has routinely projected demand into the future and has taken build decisions long before it would run out of capacity. In the 1990s, its internal calculations showed that new power plants would need to be built and brought into operation by 2007 to meet the expected growth in electricity demand. It identified suitable sites for these new power stations as well as some new pumped storage facilities. However, it was unable to implement these plans, for reasons that will be explained below.

The first alarm bells were sounded in 1998, when the Depart-

ment of Minerals and Energy released its Energy White Paper. This stressed the urgent need for additional capacity due to the growing economy and the drive for electrification of the large parts of the country that lacked grid power, a legacy of apartheid. The paper said that 'Eskom's present generation capacity surplus will be fully utilised by about 2007'. It further noted that the next 'decision on supply-side investments will probably have to be taken by the end of 1999 to ensure that the electricity needs of the next decade are met'. This warning about the timing of the new build was wise, given the long lead times in designing and building coal-fired power plants.

The 1998 White Paper was the first official national policy document that called for the extensive, albeit gradual, liberalisation of the electricity sector. It proposed to:

- vertically unbundle Eskom and create a separate transmission utility and an independent systems operator;
- introduce competition into the sector, especially in the generating segment;
- permit open, non-discriminatory access to the transmission system;
- encourage private sector participation;
- give customers the right to choose their supplier.

Unfortunately, implementation of this sensible plan was largely stalled for more than 20 years. With no imminent crisis in sight, the Government failed to act on its warnings; indeed, key aspects of the 1998 White Paper remain unimplemented.

And one of the few recommendations that the Government did pursue made things worse. The White Paper had called for policies to encourage independent power producers (IPPs) to enter the generation market. The Cabinet therefore announced that 30% of electricity generation, including renewable energy, would in future be sourced from IPPs. But in view of Eskom's overwhelming market dominance, and the reasonable expectation that its incentives would be adverse to competition by IPPs, a subsequent ruling of the Cabinet prohibited the company from constructing any new generating capacity.[47] So for at least a time, Eskom was effectively prevented from building the new capacity that was urgently needed.[48]

Despite the announcement, through the early 2000s progress in attracting IPPs into the electricity market was painfully slow. Not surprisingly, Eskom had few incentives, and no well-defined statutory obligation, to cooperate and contract with them. There was no clear institutional framework in place to facilitate their entry into the market either. For example, there was considerable uncertainty about the terms and conditions governing access to the grid. Also, it was not clear who was supposed to be the buyer of the power generated by those IPPs. More importantly, IPPs found it very difficult to compete with Eskom's below-cost tariffs.[49] And despite considerable international experience with the contract-

ing of IPPs, the design and implementation of standard power-purchase agreements proved to be a surprisingly arduous and slow process. Although Eskom subsequently signed some agreements with industrial co-generators, the quantities of power involved were tiny in comparison to the system's need for additional generating capacity.[50] Years passed without a single IPP entering South Africa's electricity market.

As a result, no new power plant was installed between 1998 and 2003 and, with the demand for electricity exhibiting robust growth, the Government was finally forced to revise its electricity policy. Eskom, somewhat belatedly, was given the green light to build new power stations. By that time, however, the system's reserve margin had already declined to just over 8%. Three years later, in 2007, Eskom's reserve margin had declined to the dangerously low level of around 5% and many of its power plants were reaching the end of their design lives. As explained above, a healthy reserve margin is necessary to allow for planned maintenance and provide a cushion to manage unplanned interruptions, without system-wide outages and ultimately a national electricity crisis. It also allows optimisation of the cost of the power system; with a reserve margin of only 5%, Eskom had very little choice but to run all the available power stations all the time, regardless of their cost profiles.

The government's decision to allow Eskom to build new capacity therefore came too late to avert the crisis. Given the long lead times for building power stations, the company sought to generate some of the extra power needed by refurbishing its older mothballed stations, but this could not close the demand gap. It was saddled with a statutory obligation to meet national electricity demand and 'Keep the Lights On'. This forced it to run its aging plants very hard, and in many instances plant components were being stressed well beyond their design operating parameters. It also meant that it had to frequently defer preventive maintenance, especially the mid-life refurbishments that are normally required to preserve technical performance and maintain availability of aging power plants. These two factors left the operating stations more vulnerable to faults, and there was a steady increase in breakdowns. Indeed, Eskom's data from the late 1990s and early 2000 show a strong correlation between the load factor (how hard a plant is being run on a percentage basis) and unplanned plant breakdowns, as measured by UCLF (Figure 16).

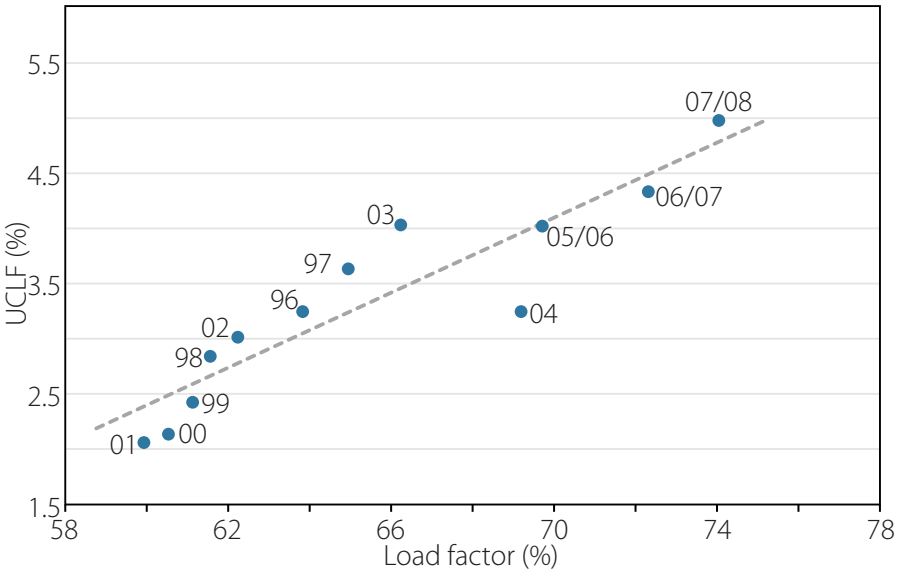
State capture, governance failure and corruption

The economics of corruption

In public utilities, capital immobility and natural monopoly conditions undermine the efficacy of market forces. The fact that public utilities are generally shielded from competitive pressures, together with their large size, makes them a natural target for, and vulnerable to, corrupt interests. Public utilities around the world are therefore often characterised by high levels of corruption.

Figure 16: Correlation between UCLF and load factor

Source: Eskom (2008).



It is a fundamental tenet of economics that where undistorted effective competition reigns, market outcomes further one of the most important aspects of the public interest: ensuring that prices be no higher than necessary to cover pertinent costs, because higher prices render entry profitable and thereby attract additional and alternative supply. Experience amply supports the proposition that competition weeds out inefficiency, encourages productivity and technological progress, and generally benefits society by providing a combination of goods and services whose qualities and attributes are adapted to the demands of consumers while using as small a quantity of resources as possible in the supply of these products.

These fundamental attributes of competition have very significant implications for corruption. In general, corruption raises the cost of doing business and ultimately the total cost of production. Therefore, firm-specific forms of corruption cannot be sustainable because those firms that tolerate it will fail to minimise their total costs of production and will be driven out of business. Moreover, even industry-specific forms of corruption are not sustainable in competitive industries because firms that vie with each other to meet customers' needs and to create business will seek to minimise all costs, especially those that are avoidable, like corruption. Lacking the pressures of competition, however, firms with monopoly power are much more tolerant towards corruption because they can easily pass the extra cost onto their final consumers in the form of higher prices, or to the government in the form of bailouts. Thus, corruption can persist in public utilities where there is considerable market power.

The problems at Eskom

In recent years, the concerted efforts of investigative journalists, civil society organisations, anticorruption activists, industry and academic experts, political parties, concerned citizens, state organs and public leaders began to expose *prima facie* evidence of state capture in South Africa. They revealed a widespread and

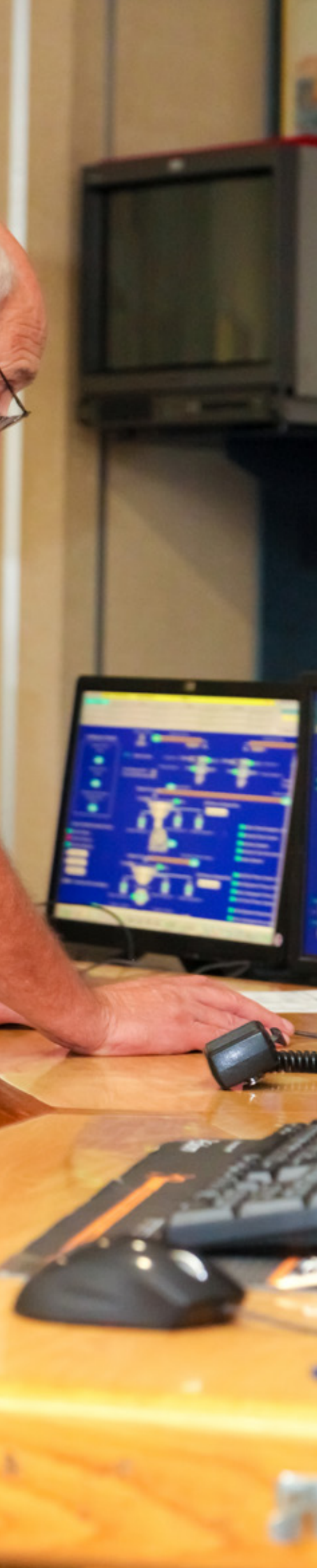
corrupt network of political and business actors, working to divert public resources for private gain. There were widespread allegations of gross negligence, mismanagement, and maladministration, in particular among Eskom's top executives. The utility's financial losses and insolvency were claimed to be in large part a direct consequence of years of corruption and mismanagement. In some cases, it was difficult to ascertain the merits of the complaints and to discern the truth from the often conflicting versions of events. However, the sheer volume of these allegations, the diverse nature of their sources, and the fact that many of them have been extensively documented, are a cause for grave concern. Some examples of the scandals that have plagued the company over the years[51] are outlined in the following sections.

Corrupt coal contracts

Procurement is one of the public utility activities most liable to corruption. [52] There are many different vulnerabilities: the volume and size of transactions, and thus the high stakes involved, and the complexity of the process and the close interactions between utility officials and supplier staff. Suppliers, aggressively pursuing profitable contracts, will exploit those vulnerabilities through a variety of corrupt acts, including bribery of utility officials involved in the contract-award process, embezzlement, or fraud in bid evaluations, invoices or contract obligations. Bid-rigging and cartelism may further undermine the procurement process.

Eskom's coal supply pipeline has been a root cause of its corruption. Indeed, some of the most blatant incidents of corruption relate to the company's coal procurement process. The problems began on a large scale in 2001.[53] After a failure in the coal mine that was supposed to supply the Majuba power station, Eskom was given an emergency mandate that allowed it to buy coal on the spot market, or from other mines, outside the long-term contracts it traditionally entered into with suppliers. Instead of using the mandate to deal with the supply problems at Majuba, however, Eskom management used it to bring coal procurement into its Black Economic Empowerment (BEE) drive. Many of the 40-year supply agreements with established coal mines were abandoned, and by 2004 52% of total coal procurement had been directed to small and mid-sized companies that had often had little relevant experience but met the BEE criteria for the mining sector. Moreover, the new mines were often far from the power stations, thus requiring transportation by rail or road. The trucks used were frequently old and under-maintained, with adverse consequences for the road networks around power stations. The coal was expensive and of mediocre and inconsistent quality, and the irregularity of its delivery rendered Eskom's inventory management more complex.[54] Moreover, supplanting normal price and quality criteria with political priorities inevitably increased the scope for favoritism and corruption.

Eskom's efforts to bypass its large, established coal suppliers was not a reflection of a genuine policy designed to redress past



apartheid inequities. Its use of its muscle in the coal industry to squeeze out the coal majors represented one of the clearest examples of state capture and corruption in Eskom's history. The coal contracts signed with collieries in the Tegeta group, controlled by the Gupta family, were examples of an extraordinarily complex web of state capture and corruption that caused irreparable damage to the public interest.

- *Brakfontein – low quality coal*. Tegeta's initial offers to supply the Majuba power station were rejected because of serious concerns related to the coal's quality. Nevertheless, after changes in Eskom's board in December 2014, Tegeta secured a five-year deal (subsequently extended to 10 years) with Eskom in January 2015. There was no financial due diligence, and a condition precedent that required a combustion test of the coal was ignored: Tegeta won the tender even though, by some reports, 29 out of 30 coal samples from its Brakfontein colliery failed Eskom's analysis tests.[55] Interestingly, the contractual price agreed with Tegeta was higher than the bids of other coal suppliers to the Majuba station. The poor quality coal delivered under the contract caused a series of plant breakdowns and the sulphur levels in the coal were of concern. In August 2015, Eskom informed Tegeta that it was suspending its coal-supply contract. Incredibly, the suspension was lifted only five days later, but four Eskom employees who had raised concerns over the quality of the coal were suspended.[56]
- *Sale of the Optimum mine*. There have been widespread allegations that a coalition of private interests – the Guptas, senior officials at Eskom and members of the Cabinet – strong-armed the conglomerate Glencore to sell its Optimum mine to Tegeta. In July 2013, Glencore invoked a 'hardship clause' due to escalating production costs at Optimum, and asked to re-negotiate its fixed-price contract with Eskom. In March 2015, Eskom's Executive Procurement Committee approved a new contract, but this was annulled soon afterwards by the utility's new acting CEO. Instead, Eskom issued a claim for R2.1 billion because, it said, Glencore had failed to meet its contractual supply specifications. With the mine's precarious financial state, Glencore was powerless and, in August 2015, it commenced business rescue proceedings at Optimum. It was then threatened with the prospect of a review of all of its coal contracts with Eskom and the cancellation of all of its mining rights. In order to save itself, it had to agree to sell not only Optimum, but also all the assets of its Optimal Coal Holdings to Tegeta, and at a massively discounted price. Incredibly, it later emerged that Eskom financed the deal, providing a R659 million prepayment to Tegeta for the coal at a price which it had previously considered unacceptable. Moreover, it continued to pay very high prices for coal from Tegeta going forward too.

Gross mismanagement – the Duvha boiler fiasco

On 30 March 2014 the No.3 boiler at the Duvha power station in Mpumulanga blew up. Eskom's internal investigation suggested that several factors had played a part in causing the problem. The conveyer belt between Middelburg mine and Duvha was damaged in December 2013. In response, Duvha changed its coal source, resulting in a different type, grade and quality of coal being fed into the boiler. Duvha was designed to burn coal from a particular source, with specific calorific values and ash properties. The new coal burned in a different way, generating less heat, more ash and more slag deposits. There was also a build-up of unburnt fuel and insufficient oxygen levels in the boiler.[57] Changes in the boiler's operating conditions can be handled by trained and experienced engineers, but the automated systems used at Duvha assumed that the coal specifications would remain constant over time. As a result, these factors, coupled with the condition of the boiler and operating practice, resulted in the failure. Moreover, because Eskom faced revenue inadequacy, the required expenditures for the maintenance and upgrading of Duvha, as in many other of the utility's power stations, were reduced and delayed. Lack of proper maintenance increased the likelihood of such plant failures.

The accident at Duvha put 600 MW of the country's generating capacity out of commission. This represented about 2% of the total available, at a time when the reserve margin was already at a dangerously low level. Given the huge risks of extensive load-shedding that resulted, it could be reasonably expected that Eskom would have pulled together the best resources in the country to rectify the situation as quickly as possible. Incredibly, nearly two years after the accident, repairs had not even started. The utility took well over a year to complete the insurance evaluation process (August 2015), while it haggled over whether the insurer should pay it cash or pay someone else to provide a new boiler.

The tender for the new boiler was delayed until December 2015. Price was supposed to be the determining factor, but the state of the existing structure and peripheral equipment was not clearly specified. And this despite the fact that Eskom engaged consulting engineers to analyse the structure that supported the blown boiler. Thus bidders were required to take all the risk for the existing plant. They were also given a very short time to prepare their proposals – much less than the three months that is the normal minimum. Not surprisingly, given the vague parameters of the tender and the many assumptions that the potential bidders had to make, the three bids that were received varied substantially in terms of the price and the responsibilities that would be accepted with the tender, the type of the boiler that would be offered and the time required for its installation. No sensible comparison could be made between the bids offered.

Eskom rejected any bids from companies that would not assume all the contractual risks – including, interestingly, one from the companies that designed and built the original boiler. Instead,

it chose to negotiate with the single remaining bidder, despite the fact that it had allegedly never built such a boiler before. With no competition among contractors, the negotiations did not go well, and nearly six months later they fell apart. For another few months nothing was heard in the industry. In June 2016, Eskom restarted the tender process, and in March 2017 the contract was awarded to the Chinese company Dongfang, whose price was actually higher and who scored far lower than the others in the safety, health, and environmental categories.[58]

One of the bidders, General Electric, accused Eskom of rigging the tender and awarding the contract to Dongfang even though its bid was R1 billion higher than that of its rivals. It was alleged that Eskom's decision to award the contract to Dongfang came just eight days after the politically connected advisory firm Trillian gave its submission the thumbs up in a last-minute risk assessment of the bids submitted. Trillian's majority shareholder, Salim Essa, was a close associate of the Gupta family.[59] In June 2017, the Johannesburg high court interdicted Eskom from proceeding with the controversial R4 billion tender. The procurement and construction of the boiler remains suspended.[60]

Governance crisis and state capture

Eskom has been extensively controlled by the government of South Africa. The government exercises control through its appointments to the utility's board of directors and executive management. Pricing, investment decisions, financial structure, accounting methods, vertical relations and operating rules have also been tightly controlled by the government.

In recent years, the crisis over Eskom's governance has become so severe that irreparable damage has been done to the public trust that it formerly enjoyed. It is now an open question as to whether Eskom can continue to play such a key role in South Africa's economic and social development, and even if it should be allowed to retain its public status. One clear indicator of the extent of destabilising political interference in the utility's governance has been the turnover of executive management. In the two years before Jacob Zuma's presidency ended in 2018, Eskom went through four board chairs, six CEOs and five chief financial officers. In the last fifteen years it has been through a total of twelve acting or permanent CEOs. Similarly, four ministers have changed in the Ministry of Energy, and five in the Department of Public Enterprises.[61] All efforts to date to restore credible governance to the utility by reconstituting its board have effectively failed.

Eskom's governance failure has been part of a broader pattern of both bureaucratic or petty corruption and 'state capture' or grand political corruption. It has been alleged, by a variety of sources, that corruption of Eskom has involved the highest levels of the political system. In November 2016, South Africa's former Public Protector released the *State of Capture* report, the result of an investigation into alleged improper and unethical conduct by the President and other state functionaries. The findings relate to

allegations of improper relationships and the involvement of the Gupta family in the removal and appointment of ministers and directors of state-owned enterprises, possibly resulting in corrupt awarding of state contracts and benefits to Gupta businesses. The report contained considerable evidence and information related to Eskom:

> President Zuma's son, Mr D. Zuma…is a business partner of the Gupta family through an entity called Mabengela Investments…Mabengela has a 28.5% interest in Tegeta Exploration and Resources…
>
> Members of the Gupta family and Mr D. Zuma have secured major contracts with Eskom…through Tegeta. Tegeta has secured a 10-year coal supply agreement…with Eskom…to supply coal to the Majuba Power station. The entity has also secured contracts with Eskom to supply coal to the Hendrina and Arnot power stations.
>
> Eskom CEO, Mr Brian Molefe…is friends with members of the Gupta family. Mr A. Gupta admitted during my interview with him on 4 October 2016 that Mr Molefe is his 'very good friend' and often visits his home in Saxonwold.
>
> *The New Age* newspaper (published by TNA Media, a Gupta-owned company) has also secured contracts with some provincial government departments and state-owned entities, most notably Eskom and South African Airways…

Prompted by widespread evidence of corruption and governance failures of South African state-owned companies, in 2017 Parliament's Portfolio Committee on Public Enterprises embarked upon an inquiry into allegations of state capture, including at Eskom. In October that year, the committee issued a report detailing *prima facie* evidence of corruption, governance failure, and poor management of Eskom.[62] High among these concerns was the steady outflow, starting in 2010 and accelerating after 2014, of the most competent and experienced personnel from the company, the people who had been responsible for the relatively good performance and stability of the organisation in the past. The committee also obtained evidence that Eskom's Board had been replaced with individuals connected to the political establishment and to the Gupta family. The newly appointed board members brought about numerous deals and financial transactions that were highly suspect. These included serious irregularities in procurement, in particular regarding:

- Eskom's relationship with Tegeta and, in particular, its role in Tegeta's acquisition of Optimum Coal Holdings;
- irregularities in Eskom's relationship with Gupta-owned TNA Media (Pty) Ltd and in the management of its IT contracts;
- controversial payments to the Gupta-linked firms and questionable contracts with McKinsey that enabled these relationships.

The committee's findings of severe breaches in corporate

governance marked a reversal of two decades of effort to improve Eskom's apartheid-era record of poor transparency and accountability. Up to the mid-2000s, Eskom had achieved a relatively high calibre of technocratic expertise, capable executive leadership and credible board membership, all of which enabled significant progress in meeting the country's electricity needs. The policy environment had also been favourable. The agenda for Eskom had been set by the Department of Public Enterprises and, in particular, by the Department of Minerals and Energy, which had been handed the formal mandate for the energy sector under the 1988 White Paper. Both departments were relatively stable during this period.

However, especially after 2010, Eskom's governance standards and performance began to deteriorate. Both the utility itself and ministerial officials misled Parliament and the public on this score, but following the publication of the *State of Capture Report* and numerous internal and external reports, and exhaustive journalistic investigation, it became clear that there had been a dramatic divergence from the standards required in the legal and regulatory framework. Between 2010 and 2018, notable transgressions included:

- political interference in the appointment of Eskom board members and executives, resulting in the selection of incompetent, compromised or corrupt people;
- misuse of disciplinary processes and human resource actions to dismiss and intimidate Eskom staff and board members, a climate of fear and mistrust, and a culture of impunity for unethical decisionmaking;
- obfuscation of lines of accountability and responsibility, interference in the integrity of investigative procedures, violation of confidentiality, and collusive behaviours intended to subvert due process;
- non-compliance with rules, regulations, standards and policies, or divergence therefrom in ways that violated their intention, without clear justification;
- deliberate lack of transparency within Eskom, including undeclared negotiations and transactions, and deliberate provision of misleading information to stakeholders at all levels, including to the board, ministerial officials and Parliament, the media and citizens.

Eskom executives and the board have not been held accountable for any of these failures or for the poor performance of the company, nor has the Ministry of Public Enterprises been made accountable for its neglect in this regard.

Artificially low prices, underinvestment and lack of proper maintenance

One of most serious defects of electricity policy and practice in South Africa is Eskom's maintenance of prices at levels well below the true (long-run marginal) cost of supplying power. By doing this,

the South African government has effectively subsidised the cost of electricity, an unsurprising decision given the strategic importance of the electricity sector in South Africa's economy, and the government's political, social, and economic priorities.[63]

It should be noted that inefficient pricing policies have been one of the most important causes of the deterioration in the performance of the electricity (and other infrastructure sectors) in developing and transition countries prior to the reform era. Those countries, unfortunately, were in even less of a position than their developed counterparts to afford the costs of resource misallocation and the production inefficiency that resulted. Price controls were frequently imposed without regard for the effects, subjecting the operating entities to considerable financial distress and substantially impairing their ability to maintain and expand service. The failure of many governments to allow adequate price increases, especially during periods of high inflation, effectively decapitalised their electricity sector. As a result, quality of service suffered. Moreover, the inability of financially impaired electric utilities to meet the requirements of modern economies constrained domestic growth and hampered international competitiveness.

Artificially low electricity prices and their attendant government subsidies can cause significant economic harm and distortions. They can:[64]

- crowd out growth-enhancing or public spending to benefit the poor;
- discourage investment in the electricity sector and thus precipitate supply shortages;
- create harmful market distortions – e.g. they promote investment in capital-intensive and energy-intensive industries;
- stimulate demand and encourage wasteful use of electricity;
- have adverse distributional impacts – they tend to benefit mostly higher-income households.

South Africa is a case in point. Real electricity prices were allowed to decline throughout the 1990s, and by early 2000 they were well below the cost of supply. These prices provided poor signals to potential investors; given that Eskom's prices were below cost, no private entrant could compete, and so government attempts to attract private investment to the sector were frustrated, thus helping to precipitate the power supply crisis that emerged in 2008.

The low electricity prices also encouraged the inefficient use of energy, thus contributing to South Africa's becoming one of the largest contributors to global greenhouse gas emissions. In the wake of the sharp increase in real electricity tariffs in recent years, several large consumers of electricity have reported efficiency gains. This suggests that subsidised electricity prices in the past reduced the incentive for investment in energy-efficient technologies.

Finally, tariffs below the cost of supply meant that Eskom was chronically short of revenue, and thus was unable to finance maintenance and new investment from internally generated funds. As a result, it was forced to seek government support. Such dependence on government bailouts inevitably led to increased lack of autonomy and political interference in its day-to-day affairs, and thus to a further loss of efficiency.

6. The new restructuring plan…and its risks

In 2019, following the recommendation of a team appointed by the President the previous year, it was announced that Eskom would be unbundled. There would be three separate subsidiaries, covering generation, transmission, and distribution, each with its own management team, and with a holding company to oversee everything. It was also announced that Eskom would be supported by 'an allocation' of R23 billion per year for the next decade.[65] This restructuring had been a long time coming. It was first proposed and formalised 20 years earlier in the 1998 White Paper, but the 2019 decision was motivated by the utility's financial distress, with ongoing financial losses and a growing debt, as well as public concern over the extensive load shedding.

The case for unbundling

Two basic arguments can be made in support of the government's restructuring plan. The first is that the act of splitting Eskom into components that are managerially and financially independent is so revolutionary that it may unsettle the utility's business culture in a productive fashion, thus bringing about the necessary internal reorganisations of responsibilities, roles, incentives, and information flows. By this reasoning, the restructuring could improve managerial performance, increase the transparency of operations and finances, isolate the sources of existing problems, mitigate corruption and attract private investment.

The second argument is that unbundling may facilitate a more rapid and larger-scale deployment of renewables, which might contribute to resolving South Africa's electricity crisis. In the past, Eskom has effectively decided whether to build additional capacity itself or to allow the private sector to do so. In 2016, for example, Eskom refused to sign power purchase agreements with private companies that had been mandated by the Department of Energy (DoE) to develop renewable energy systems. The refusal to implement the agreements halted 37 IPP projects worth R58 billion. Eskom's senior management was adamant that the projects – while approved by the DoE – would have had a negative impact on the utility's balance sheet.[66] The separation of Eskom's generation, transmission, distribution and other supply activities largely removes conflicts of interest that may occur in the vertically integrated utility, where it is generating its own power while also being a single-buyer from IPPs.[67]

Historically the electricity industry has had a monolithic structure, with a single entity owning generation and transmission capacity and performing all system operations and administrative functions. Due to technological and other fundamental economic changes, the conditions that generated this model no longer exist in most countries. Indeed, in the last three decades, there has been an increasing recognition that the electricity industry is not monolithic but rather encompasses a number of distinct activities with entirely different economic characteristics. Electricity is a vertical industry, characterised by transportation (a hierarchy of transmission links) and distribution networks linking upstream production with downstream consumption. These networks entail substantial fixed costs that are largely sunk because the assets are of minimal value for other purposes. The sunken nature of transmission and distribution infrastructure mitigates against freedom of entry, especially since the incumbents' huge fixed costs make them natural monopolies.

The cost conditions relating to upstream generation and downstream supply activities are less inimical to competition. Although there are important economies of scale and inevitably some sunk costs associated with these activities, they are small in relation to those encountered in the transmission and distribution sectors. Therefore, there is no question that substantial competition could emerge in many activities in the electricity sector if it was properly reorganised. As a result, governments throughout the world have taken substantive steps to restructure and deregulate their electricity industries. The objectives for such restructuring and regulatory reform programs have included:

- introduction of more innovative and efficient management
- competition, leading to lower prices
- increased efficiency
- responsiveness to the needs of consumers and businesses.

Unbundling is no panacea

However, there are several links in this chain of policy reasoning behind moves to unbundle electricity systems that may be inapplicable in the case of South Africa.

Firstly, the plethora of new technologies has effectively rendered electricity a multidimensional service. The most straightforward dimension is 'energy', determined by the amount of electricity delivered, the timing, and location. But as energy is used for different reasons – say for charging a battery, running a refrigerator, or watching TV, different types of industrial and commercial activities (e.g. aluminium and iron smelting, sophisticated electronic manufacturing), residen-

tial cooling and heating – the need for reliability will differ too. Users' tolerance thresholds regarding reliability, comfort, or convenience, which are indirect services provided by electricity suppliers, will not be the same. Other intangibles, such as the value of emissions not emitted, or even the value of non-consumption of energy for the system, may also be important.

Secondly, the increasing penetration of renewables and the need for a variety of innovative and market-responsive electricity services may require maintenance or upgrading of network infrastructure – an important consideration in South Africa, given the extent of the disrepair of such facilities on Eskom's watch. It may be difficult for an electricity service supplier to coordinate with the infrastructure monopoly, especially if the two organisations' incentives with respect to investment behaviour are not aligned. The incentives of the infrastructure monopolist will, of course, depend critically on whether it is a state-owned entity or, if it is in the private sector, on the character of its regulation.

Thirdly, efficient utilisation of the transmission/distribution network requires close coordination between generators, downstream suppliers and the monopoly infrastructure operator. Competing generators, for example, will compete vigorously and acrimoniously over scarce or congested transmission facilities, and constantly sorting out their claims will be important for the overall efficient and responsive operation of the electricity system. This would be difficult for an unintegrated system with a monopoly infrastructure entity, but it seems virtually impossible to accomplish efficiently under conditions of rules against discrimination and infrastructure pricing that is either tightly regulated and/or, for a state enterprise, politicised – the latter being a high probability risk in the case of South Africa.

Finally, efficient pricing to recover infrastructure replacement costs is made more difficult by separation. Where economies of scale are important, efficient pricing to cover replacement costs requires that different services on the network bear prices with different relationships to marginal costs. If it is the case that the operator firms can readily evade price discrimination on the part of the infrastructure entity, so that different prices cannot be collected by the infrastructure entity for facility utilisation by different operators offering different services, then it will be difficult, if not impossible, for the costs of the infrastructure to be efficiently defrayed. At the extreme, a regulated infrastructure entity charging competing operators an equal price for each unit of utilisation of its facilities is, in essence, recreating a system where prices are set according to fully allocated costs. Such pricing can be a prescription for inefficiency and persistent revenue inadequacy.

Thus, it is clear that vertical separation of operations from infrastructure is no panacea (Table 1). Instead, as a policy direction, it must be compared with the leading alternatives. The potential benefits and the social costs of vertical relationships have been extensively analysed.[68]

Table 1: Benefits and social costs of vertical unbundling.

Benefits	Social costs
Promotes competition	Loss of coordination across layers
Reduces the scope for regulation	Loss of coordination between operations and investment
Facilitates innovation by allowing single-layer entry	Defined interfaces can create rigidities that constrain innovation
Facilitates greater cost transparency	Complicates the efficient recovery of infrastructure costs

One of the most important benefits of unbundling is that it promotes competition: it prevents market power in the most concentrated or natural monopoly segments (transmission and potentially distribution) from driving or infecting the entire industry; it also allows smaller players to enter the market. Moreover, it can facilitate innovation by permitting the entry of different technologies (e.g. renewables) and by allowing single-layer innovation. Structural reforms of this kind, therefore, have the potential to spur significant cost reductions, to increase dramatically the diversity of fuel technologies and price-service options facing consumers, and to expand service to those who currently lack access, especially poorer rural households.

Unbundling can lead to important gains in efficiency. However, it inevitably leads to the loss of coordination economies, which in the electricity sector (e.g. between generation and transmission) can be quite significant and makes it difficult for the costs of physical infrastructure (transmission and distribution) to be recovered in an efficient manner. Also, the conditions for effective competition in the utilities have proven more demanding than in normal product markets.[69] Moreover, unbundling can create some new challenges for regulatory policy. It is true that it can narrow considerably the need for regulatory intervention, but it is also true that the performance of unbundled network systems is much more sensitive to the correct application of regulatory rules than the monolithic industry structure. In fact, certain inefficient regulatory practices that were more or less tolerable under the old vertically-integrated monopoly structure can have much more serious consequences in the new setting.

Separation of infrastructure assets from operations is likely to be a particularly attractive option where a large market permits many operators (generators and possibly retailers) to function, and to provide both active and potential competition to each oth-

er. Another favourable factor is a mature and well-developed set of fixed (transmission and distribution) facilities, so that there is relatively little need for new infrastructure investments, for which incentive problems are more likely to arise. The first condition relating to the size of the market applies in the case of South Africa's electricity system. However, the second does not apply given the extent of disrepair of Eskom's fixed facilities. That being the case, the challenge will be for regulation of the infrastructure entity to permit it to enter into medium- or long-term contracts with end-users or with operators that themselves have contracts with end-users, so that the risks and rewards from investments can be efficiently shared by end-users, operators, and the infrastructure entity. Finally, there may well be circumstances where a monolithic utility cannot be converted to one with a well-functioning vertical structure because of imbedded business culture and entrenched management. The experience from the past twenty years clearly indicates that this is the case with Eskom.

7. Promises and limitations of renewables

Throughout the world, there are high expectations that technological innovation will play a critical role in facilitating the transition to a low-carbon economy, and considerable excitement about the growing importance of renewable technologies in the future energy mix. Already, as part of their efforts to reduce greenhouse gas emissions and improve the security of their energy supply, many governments have made similarly worded pronouncements and set ambitious goals for sourcing a significant portion of electricity from renewables.

Renewable energy sources are indigenous and abundant – and their use could significantly increase the long-term security of energy supplies and reduce greenhouse gas emissions. Governments have recognised that for the less mature technologies (solar, offshore wind, wave, and tidal stream) current costs are both high and a poor guide to what is ultimately achievable. Thus they are providing support, through carbon prices, feed-in tariffs, and renewables obligations, and are beginning to address problems of intermittency through better grid design and management, and the application of advanced storage technologies.[70]

World leaders from nearly every country set ambitious goals to fight climate change and to slash their greenhouse gas emissions. Those commitments have generated considerable optimism. However, the majority of countries have not been following through on their promises.[71] South Africa is typical among countries whose energy mix is heavily dominated by fossil fuels and have failed to substantially transition toward renewable sources. Indeed, there is a marked discrepancy between official government pronouncements and commitments on decarbonisation, and actual progress in reducing the country's extreme reliance on coal. Progress to date has been painfully slow.

The case for renewables in South Africa

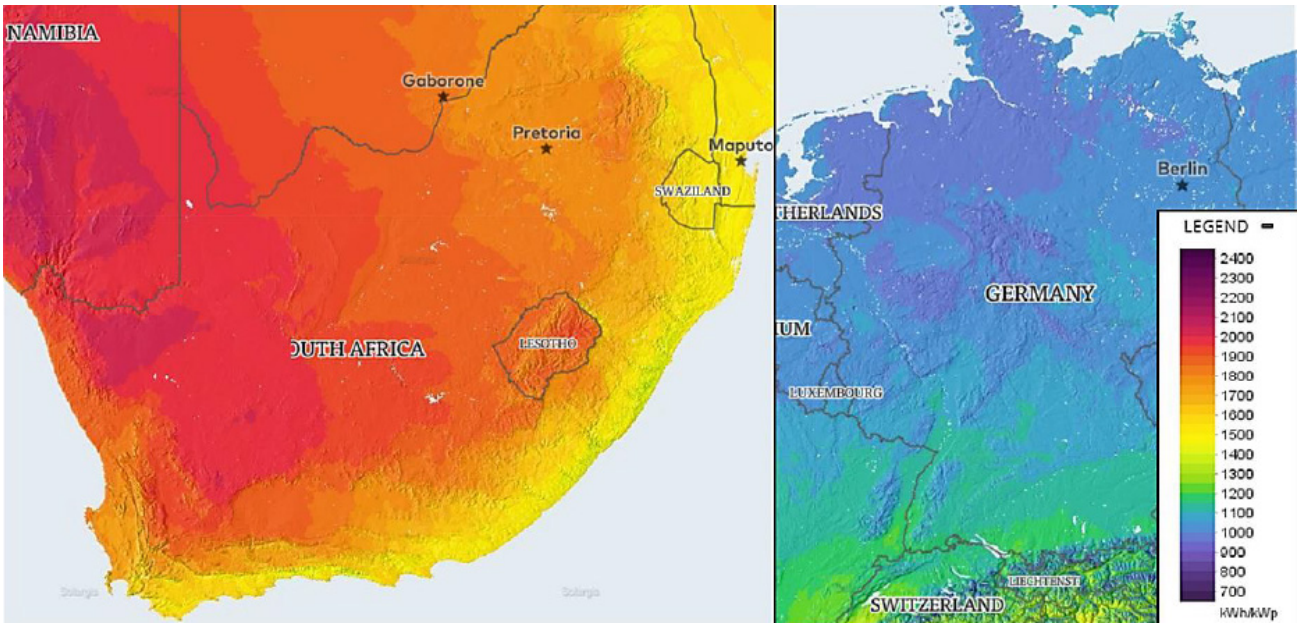
South Africa has very substantial wind and solar PV resource potential. Indeed, there are only a few countries around the world where wind speeds or solar irradiation are as high. For example, a solar PV installation in South Africa would generate almost twice as much energy as a comparable installation in Germany (Figure 17) – a country which has installed PV systems with a nominal capacity of 49 GW.[72]

By some estimates, South Africa's wind and solar potentials exceed by far current and expected future demand. Over 220 GW of solar PV potential has been identified in the country's Renewable Energy Development Zones (REDZ). Moreover, wind turbines could achieve extraordinarily high load factors; above 30% in many parts of the country. Between 55% and 65% of South Africa's land mass has average wind speeds that would allow load factors in excess of 35%. Some large areas even offer load factors approaching 40%. More than 80% of South Africa's land mass has rich enough wind resources to support low-cost wind energy. And South Africa is a large country, with a low population density, and thus could easily meet the estimated space requirements of renewables.[73]

Proponents of renewables also argue that in addition to possessing some of the best solar and wind resources in the world, there are other important factors suggesting that South Africa would benefit from a more rapid transition to renewables. Eskom's failure to provide a reliable electricity service has been devastating to South Africa's economy, especially the mining and industrial sectors. And it is a serious impediment to attracting foreign direct investment. It is suggested that rehabilitation of old and under-

Figure 17: Comparison of the solar PV production potential in South Africa and Germany.

Source: Wright et al. (2017)..



maintained coal-fired stations would be prohibitively costly, while replacement with new coal-fired plants might fall foul of escalating global pressures for the decarbonisation of electricity systems; the risk of their becoming 'stranded assets' would deter private investors.

Limits on rapid deployment

The rapid deployment of renewable technologies in South Africa is likely to encounter several major hurdles. Some of these barriers underlie the integration of large amounts of renewable energy in every country. Others are likely to arise from the enormous operating challenges and performance problems of the South African system.

Compared to conventional thermal generation, wind and solar exhibit five characteristics that may pose significant grid integration challenges (Table 2). As a result, the costs and practicality of grid integration of large quantities of renewable energy have been questioned and have become a focal point of national and international research.

Wind, solar and other renewable generating technologies are not dispatchable in the traditional sense. Their production levels are driven by a variety of weather characteristics: wind speed and direction, cloud cover and haze. Consequently, they cannot be controlled or dispatched by system operators based on traditional economic criteria. The output of intermittent generating units can vary widely from day to day, hour to hour, or minute to minute. Rather than controlling how much electricity is delivered by a generator, and when, with renewables, system operators must respond to what comes at them, calling on generators that are dispatchable to maintain network frequency and other grid reliability parameters.[74] Thus, there are a number of technical issues associated with integrating large amounts of wind and solar capacity

Table 2: The five major challenges of renewables

Variability	Output varies as the underlying resource fluctuates	Balancing generation with electricity load requires more system flexibility
Uncertainty	Output cannot be predicted with a high degree of accuracy (day-ahead, day of)	System operators generally need additional reserves to maintain system integrity and stability
Location-specificity	Generation is more economical in locations where the quality of the resource is high	More investment in transmission and more advanced system-wide planning could be needed
Non-synchronous	Generators provide voltage support and frequency control in a different manner than traditional resources	Voltage and frequency stability from variable RE generators or additional equipment comes at added capital and/or opportunity costs
Low capacity factor	Availability of the underlying energy resource limits the run- time of the plant	Existing conventional generators could be needed to meet demand, but run at part load, affecting their efficiency and cost recovery

into an electric power network. A large increase in renewables will therefore certainly necessitate substantial investment in reserve capacity.

Another important problem is that the most efficient sites for renewable energy, especially wind and large-scale solar facilities, are often located far from load centres. Significant investment in new long-distance transmission facilities will therefore also be required.

Importantly, greater flexibility in the system may be needed to accommodate the supply-side variability. Flexibility can substantially reduce the need to curtail solar and wind output, mitigating the risk of negative market pricing, which results when conventional generators cannot sufficiently reduce output during times of renewable oversupply. It can also reduce the environmental impacts of power system operations via increased optimisation of demand response, more efficient use of transmission, and reduced renewable curtailments.

Flexibility is system specific. For example, all else being equal, power systems utilising a diverse set of primary energy inputs (e.g. natural gas, wind, hydro, pumped storage, geothermal) will be more flexible than ones dominated by coal or nuclear. And one of the clearest indicators of system inflexibility is when such a system has difficulty balancing demand and supply, which, as we have seen, is the case in South Africa. Since it can take several years to design and build new generating and transmission capacity, the planning process is the first critical activity to ensure that the power system of the future possesses sufficient flexibility to accommodate the growth of variable renewable generation.[75] But it is precisely the near absence of planning and investment clarity in South Africa's electricity sector that led to the lack of adequate generating capacity and resulted in the power system not having sufficient flexibility to operate efficiently. So renewables penetration in South Africa is likely to be limited by a lack of operational flexibility and transmission availability. The economic carrying capacity – the level of renewables at which that generation is no longer economically attractive to the system or society – of South Africa's power system is likely to prove to be quite low given the system's lack of fuel diversity, low plant availability rates, and critically tight reserve margins.

The integration of substantial quantities of wind and solar power in electric grids can have significant negative impacts on gas- and especially coal-fired generators. High penetrations of wind and solar can cause such plants to cycle more frequently in response to intermittency. Cycling of fossil-fuel generators can induce thermal stresses on their equipment, leading to an increase in wear-and-tear, and ultimately a decrease in efficiency. In general, coal-fired units have the highest cycling costs (although gas turbines can also have significant costs; hydropower stations and diesel generators have the lowest cycling costs[76]). Cycling can cause significant damage to their boilers, reduces efficiency,

increases fuel use, and leads to difficulties in maintaining steam chemistry and NOx control equipment. With coal-fired stations already in a state of disrepair, these additional problems would be a major barrier to the rapid integration of large quantities of renewable technologies in South Africa's electricity system.

The transition to any renewable energy system in South Africa will therefore be challenging. The promises of wind and solar proponents must therefore be subjected to a careful reality check. Our emphasis on the technical headroom of alternative generating technologies does not seek to supplant the time-honoured economic cost-benefit analysis. Nor does it question the power of the incentives provided by market pricing mechanisms for the efficient allocation of scarce energy resources. However, the solutions to the twin challenges of electricity shortages and decarbonisation in South Africa are likely to prove complex, with several important technical (scientific and engineering) and social (economic, political) dimensions to consider. There is a need to consider more carefully the powerful physical constraints the alternative generating technologies must respect – constraints that cannot be relaxed through economic policy measures and tax incentives.

Reforming market design

The organisational and regulatory framework for the electric power sector in South Africa is not conducive to supporting a large-scale deployment of renewables. Regulatory distortions that may undermine efficient responses to carbon prices will also need to be dealt with. Moreover, when decarbonisation policies are adopted, it is important that market or regulatory mechanisms work effectively to convey to consumers price signals that include the price placed on carbon dioxide emissions.

One of the general drawbacks of unbundled electricity systems is that no member of the industry has the needed combination of incentives and ability for system-wide planning. This has profound implications for the adequacy and locational efficiency of new transmission and generating capacities. It is unclear if transmission investment will be adequate, timely, and efficiently used. Paying mechanisms for reserve capacity have also proven especially problematic in unbundled systems. Electricity sector regulation needs to find ways to overcome these challenges without negating the benefits of unbundling. These problems will be made worse by increasing fractions of highly decentralised and/or intermittent renewables.

There is widespread agreement that liberalised, unbundled electricity markets are poor at encouraging large-scale investment in, and deployment of, renewable and other low-carbon generating technologies without an adequate carbon price. There is a danger that if a large fraction of generation is intermittent (like wind or PV), the current market designs will fail to operate as planned. Large-scale deployment of renewables will require substantial new investment in transmission capacity. It will also require considerably larger reserve capacity. Without an adequate

carbon price, incentives for undertaking these necessary investments will be blunted. Even with a significant carbon price, moreover, it is necessary to consider the costs as well as benefits from large-scale deployment of very decentralised and/or intermittent low-carbon options.

Thus in South Africa there is an urgent need to consider ways to strengthen both the existing and proposed electricity market arrangements and mechanisms for supporting low-carbon technology options. Both are important, and failing to consider them together can amplify the economic risks that arise from electricity system performance, increase the cost of domestic support programs for low-carbon technologies, and reduce the incentives for speedy deployment. None of the above issues has been addressed in the government's announced plans for unbundling Eskom and for substantially increasing the share of wind and solar PV in the country's future energy mix.

8. An agenda for policy action

We outline below the key elements of the potential policy response to address the power crisis in South Africa and meet the energy requirements of the economy.

A fundamental tenet of this report is that there is an urgent need to substantially restructure the relationship between government and the electricity sector. The government's decision to unbundle Eskom was a step in the right direction. However, the announcement has been a long time coming. It was first proposed and formalised 20 years ago in the 1998 White Paper. And the restructuring plan has already been watered down. Eskom's new CEO, André de Ruyter, has recently downplayed expectations by referring to 'divisionalisation' rather than unbundling, and has clarified that the plan is not to carve up and sell any part of Eskom, or let any private players assist in the running of the new companies. Moreover, Eskom will not be bringing any fresh talent into the running of the new entities. The boards of the generation, transmission and distribution divisions will be populated by existing Eskom management – to avoid duplicating costs, according to de Ruyter.[77] Given the magnitude of South Africa's electricity crisis and the extent to which Eskom has been plagued by mismanagement and corruption, the government's (or Eskom's) plan, as it stands, now falls far short of what needs to be done. It is unlikely to unsettle sufficiently Eskom's imbedded business culture and entrenched management.

The case for radical measures

In most developing countries, the primary push for electricity (and more broadly infrastructure) restructuring came from the debt and fiscal crises of the early 1980s. Another major impetus was the extraordinarily weak performance of the electricity sector in those countries relative to the advanced industrial economies. Similar issues motivated reforms in transition economies, starting in the

early 1990s: heavy debt burdens forced many countries to make fiscal adjustments that hit public investment in infrastructure, including electricity, especially hard.

Restructuring was also spurred by the intolerable damage caused by mismanagement of public electric utilities. Most such entities pursued multiple, poorly defined, conflicting objectives, with managers often appointed based on their political loyalty, not competence. Investment funds were frequently squandered on poor projects. Moreover, price controls were imposed without regard for their performance implications, subjecting enterprises to financial distress and impairing their ability to mobilise investment and provide reliable services. Electricity blackouts became one of the defining characteristics of developing countries.

In a globalised economy, poorly performing state-owned electricity systems were increasingly seen as constraining economic growth and undermining international competitiveness. Developing countries simply could not continue to absorb the fiscal burden of these systems. Around the world, it became evident to policymakers that the problems of public electricity systems could be solved only by implementing radical structural changes and realigning the roles of the government and the private sector.

The factors that had prompted electricity restructuring and privatisation reforms in developing countries were not nearly as compelling in South Africa when the reforms started in the early 1990s. Eskom was then a well-functioning utility, even by advanced industrial country standards. It had managed to achieve most of its developmental obligations, delivering a highly successful electrification program while at the same time charging some of the lowest tariffs in the world and maintaining very good operational and financial performance. Moreover, it was entirely self-financed, through internal reserves and debt raised on the domestic and international capital markets, without government guarantees. Thus, unlike many other state-owned utilities, it was not draining the state budget or diverting scarce public resources from other social purposes. Finally, the South African economy did not face the macroeconomic instability and external sovereign debt problems that provided the initial impetus for privatisation in other developing countries.

Today, however, the factors that prompted radical restructuring elsewhere are even more compelling in the context of South Africa. The electricity sector is now facing the worst crisis in its history. Once heralded as South Africa's crown jewel, Eskom is now being described as the biggest risk to the country's economy. It is unable to cover its costs and make the huge interest payments on its mountain of debt – it is effectively insolvent. By its own admission, it has been delinquent with maintenance for a number of years now. Its poorly maintained power plants are struggling to meet demand, and it has gone through ten chief executive officers in a decade. Moody's Investor Service and Standard & Poor's have cut their ratings of Eskom to non-investment grade – in other

words, junk status. And late last year, Moody's revised the outlook on South Africa's last investment-grade credit rating from 'stable' to 'negative' due to the continued deterioration in the country's economic growth trajectory and public debt burden.[78]

A radical and accelerated restructuring program

Incremental structural reforms may have been successfully implemented in countries with well-functioning electricity systems. For a variety of reasons, which have been discussed throughout this report, the reform process in South Africa has been uneven and painfully slow. The Government's strategic plan for restructuring the sector, as envisaged in the 1998 White paper, remains largely unfulfilled. An incremental approach to sectoral reform may no longer be the right prescription for a country like South Africa, where the power sector is facing a crisis of unprecedented proportions. Moreover, the status quo in the electricity sector cannot be maintained for much longer. Eskom's downward spiral continues to accelerate. There is need for immediate action. De Ruyter's admission that the 'divisionalisation' is also not going to be completed any time soon is highly problematic. In the face of substantial investment requirements, far-reaching reforms that envisage much more aggressive privatisation and competitive restructuring (including ownership unbundling rather than simple divisionalisation) should not necessarily be viewed as a radical program for reform; instead they may be a sensible, even a conservative, response to a desperate situation.

Eskom's extreme vertical and horizontal market dominance, and especially its control of the industry's bottleneck network facilities, is a primary impediment to the future competitive developments in the sector. The integrated firm has strong incentives and a proven ability to make it very difficult for other entities to participate in South Africa's electricity business. Private entities will simply be reluctant to enter into the electricity industry and make substantial investments if the industry's essential facilities are controlled by Eskom – a likely competitor in the downstream provision of electricity services to final users.

Eskom's continued vertical and horizontal market dominance may also inhibit the integration of electricity markets across the region. The other countries in the Southern African Development Community may view Eskom – the largest utility in the region by far – as posing too serious a threat to the survival of their smaller national operators; integration would be viewed as likely to facilitate its dominance and monopolisation of the region's electricity markets. Also, as a vertically-integrated utility, Eskom will generally have strong incentives for self-dealing and self-preference (e.g. for its own generating stations) and thus could hinder the interchange of power and the extent of cross-border competition that could emerge.

The benefits of an accelerated program of restructuring and privatisation in South Africa's power sector could be substantial. First, if the experience from other countries is of any relevance,

private investment can be instrumental in bringing about restructuring necessary to improve overall sectoral performance. It can introduce superior financial, technical and managerial resources, bring greater clarity and transparency to the industry, force the de-politicisation of tariffs, and encourage a procurement environment based on competition and cost-effectiveness rather than political preference. Moreover, attracting foreign investment to the power sector will provide a powerful signal to potential investors in other economic areas about South Africa's policy environment.

Privatising the distribution segment

Numerous studies[79] and consultations[80] in the last 20 years have created a consensus that the problems in the electricity distribution industry needed urgent attention. High levels of non-payment for services, inadequate asset management and levels of recapitalisation, and a lack of appropriate technical resources at the municipal level are contributing to an alarming deterioration in the condition of distribution assets. A number of surveys conducted by the National Electricity Regulator have revealed growing dissatisfaction among customers, mainly due to worsening reliability. There have also been growing complaints that municipal distributors pay inadequate attention to the needs of customers.

One of the key structural deficiencies of the distribution industry has been excessive fragmentation – there are too many small, non-viable, poorly-run municipal distributors. In June 1999, after several years of studies and consultations, the Cabinet finally approved a plan to merge the large number of municipal distributors and Eskom's distribution businesses into six regional electricity distribution companies (REDs). However, implementation has been painfully slow and convoluted. The first RED was established only in 2005 and only on paper.[81] Moreover, Cabinet memos and interventions by National Treasury officials have created uncertainty and confusion about the consolidation model that will ultimately be implemented. The original plan, if implemented, will:

- correct the past failure of small municipal distributors to capture economies of scale, skill and specialisation;
- reduce the substantial differences in the financial status of municipal distributors and the wide disparity in the prices paid by geographically segmented customer groups.

However, unfavorable microeconomic conditions were not the only cause of municipal distributors' problems. Governance, non-payment, and the municipalities' traditional dependence on electricity revenue to fund other public services were also important contributing factors. The merger and consolidation of municipal distributors is unlikely to adequately address these problems, or even address them at all. To the extent that governance problems at the municipal level and the performance of local economies were major factors, a more promising direction for restructuring and reform would be to remove distribution from direct municipal control.

International experience seems to indicate that an effective way to start and sustain revenue collection discipline, as well as to introduce pricing and other reforms critical to the viability of electricity distribution, is to separate the distribution monopoly from the rest of the industry, privatise it, and subject it to price or revenue-cap regulation. A careful assessment of the applicability of this experience would clearly require taking into account country-specific differences in terms of national priorities and development plans, socioeconomic characteristics, historical perspectives (the manner in which the electricity sectors evolved and currently operate), and the role of institutions and their networks. Still, it is the position of this report that the government's decision to retain the distribution industry under municipal ownership needs to be re-examined.

Private participation and competition in generation

In recent years, technological advances have dramatically altered the cost structure of the electricity generation industry and have recast its economies of scale, reversing a multi-decade trend towards large centralised power stations. Combined-cycle gas turbines can be brought online faster (within 2 years) and at a more modest scale (50–500 MW) than coal or nuclear plants (5–10 years and 1000 MW). Aero-derivative gas turbines tend to be very compact and can be efficient at scales as small as 10 MW. Although natural gas and light oil distillates are preferred, a wide variety of low-calorific fuels have also been used successfully. Biofuels are a promising sustainable option. Thus, gas turbine technology could play an important role, even in a country like South Africa that lacks substantial natural gas resources.

Renewable technologies (wind and solar in particular) have been accelerating down cost curves and their proponents are arguing that they are becoming competitive with thermal power. As a result, and because of increasing concerns related to global warming, there has been a resurgence of interest in replacing coal-fired generation with renewables, including solar, wind power, small hydro, biomass, landfill gas to energy, and waste to energy. Moreover, renewables are especially well-suited for distributed generation – i.e., energy produced on or very near the site of use from relatively small (typically less than 30 MW) modular generating units. Owing to South Africa's substantial wind and solar PV resource potential, there is scope for significant renewables entry into generation.

In nuclear power, small modular reactors (SMRs) have been attracting considerable attention around the world. SMR designs incorporate innovative approaches to achieve simplicity, modularity and speed of build, passive safety features, proliferation resistance, and reduced financial risk. SMRs have a number of features that might make them an attractive option for countries like South Africa. The incremental capacity expansion associated with SMR deployment could provide a better match to limited grid size than conventional, large-scale reactors. They also allow for a diverse

set of useful applications – low-carbon electricity generation in remote locations with little or no access to the grid, industrial process heat, desalination or water purification, and co-generation applications. And SMRs provide an expanded set of potential siting options: their small size makes them suitable for small electric grids or for locations that cannot accommodate large-scale plants.

Due to these advances in technology, competition has arrived in the power generation business. A confluence of factors – the rapidly declining costs of renewable energy, exciting developments in gas-turbine technologies, and the need to retire ageing and uneconomic coal-fired plants – offers policymakers in South Africa a once-in-a-lifetime opportunity to creatively transform and competitively restructure the generation segment of the country's electricity system. The benefits of competition in generation could be substantial. The experience from other countries and sectors amply supports the proposition that undistorted and effective competition is the most powerful force towards economic efficiency, taking advantage of technological change to serve the public interest. Competition among private generators weeds out inefficiency, encourages innovation and technological progress, and exerts downward pressure on the cost of producing and distributing electricity. Such competition is also more likely to facilitate the deployment of emission-free technologies. Moreover, competition could mitigate the corruption that has plagued South Africa's electricity industry in recent years. Continuation of the current market structure, on the other hand, with vertically-integrated, state-owned Eskom controlling the majority of generation assets, will deny South Africa the possibility of reaping these benefits.

A prime objective of public policy in South Africa's electricity sector should be to promote and maintain a process of effective competition in generation, with a view to inducing more efficient resource allocation. Privatisation, along with other instruments of microeconomic policy, could contribute towards that goal by altering the structure of incentives and opportunities of decision-makers within firms. If the experience from other countries is of any relevance, privatisation of generation has significant positive effects on efficiency (labour and total factor productivity), financial performance, and the quality of electricity supply.

South Africa must choose among imperfect options

This report takes the view that there is no universally appropriate model for restructuring the electricity sector. And the fact that state ownership is flawed does not mean that privatisation is appropriate for the sector, or even parts of it. Before state ownership is supplanted by another institutional setup in South Africa, it is essential to assess the properties and requirements of the proposed alternative, taking into account the sector's features (its underlying economic attributes and the technological conditions of its production) and the country's economic, institutional, social, and political characteristics.

In electricity, wholesale competition has worked well in industrial countries because of excess capacity, moderate demand growth, and the availability of natural gas (which enabled the entry of gas-fired plants at modest scale and relatively low cost). In contrast, the South African electricity market is facing a very tight demand/supply balance, and load shedding. Thus electricity restructuring and privatisation are likely to prove more challenging and dependent on administrative ability. California's experience has shown that market liberalisation under conditions of tight demand (reserve margins below 10%) can lead to high and volatile prices, which would be politically unacceptable in South Africa, and would likely derail attempts at radical reform. Unbundling introduces price risks between generators and suppliers that require contracts and hedging instruments to guard against unanticipated events that might dramatically affect spot prices. And in interconnected systems operating under a variety of jurisdictions, spare capacity is a public good that may not be adequately supplied unless pricing policies are put in place to ensure its adequate remuneration.

Given the unique economic characteristics of the electricity industry – especially the need for coordination between generation and transmission, and the difficulty in replicating vertical relationships with market mechanisms – Eskom's vertically integrated structure has some appeal. In theory, the integrated company could minimise the cost of meeting demand at each point in time through optimal dispatch of its power stations, taking into account system-wide transmission constraints and losses. In the long run it could exploit the investment interrelationships between generation and transmission and undertake investments based on system-wide planning.

But these benefits will likely be small relative to those that come from promoting competition in generation: lower construction and operating costs, incentives to close inefficient plants, and better pricing. Recent technological advances have dramatically altered the cost structure of electricity generation, and this, together with the size of the electricity market in South Africa, means that extensive competition should now be possible.

The experience of the past twenty or so years demonstrates quite clearly the extreme difficulty of insulating public enterprises like Eskom from the damaging consequences of fluctuating political interference in South Africa. This experience has also highlighted the haphazard relationship between political agendas and economically efficient performance. The politicisation of Eskom's business resulted in a poorly managed company, with political rather than economic decisions triggering investment, procurement, and the pricing of many important services. Eskom's substantially deteriorating performance, taking it close to bankruptcy, and its attendant problems of extreme governance failure and corruption, should raise serious doubts about the efficacy of continued public ownership. In view of this experience, there can be

no credible government commitment or promise to wall-off state-owned Eskom from political management and interference in the future. On the other hand, government would find it more costly to induce a privately-held (albeit regulated) Eskom to act against its profit interest for the sake of its political agenda.[82] Indeed, privatisation might be the only realistic option to insulate the electricity sector from damaging and corrupting political interference and thus to resolve the sector's unprecedented structural, operational, and financial challenges.

Appendix: South Africa's power generation fleet

Type	Name	Location	Type	Capacity (MW)
Baseload stations				
	Arnot	Middelburg	Coal	2352
	Duvha	Witbank	Coal	3600
	Hendrina	Hendrina	Coal	2000
	Kendal	Witbank	Coal	4116
	Kriel	Bethal	Coal	3000
	Lethabo	Sasolburg	Coal	3708
	Majuba	Volksrust	Coal	4110
	Matimba	Lephalale	Coal	3990
	Matla	Bethal	Coal	3600
	Tutuka	Sanderton	Coal	3654
	Kusile	Ogies	Coal	799
	Medupi	Lephalale	Coal	1588
	Koeberg	Cape Town	Nuclear	1940
Peaking stations				
	Gariep	Orange River	Hydro	360
	Vanderkloof	Orange River	Hydro	240
	Drakensberg		Pumped storage	1000
	Palmiet	Grabouw	Pumped storage	400
	Ingula	Ladysmith	Pumped storage	1332
	Acacia	Cape Town	Gas	171
	Port Rex	East London	Gas	171
	Ankerlig	Atlantis	Gas	1338
	Gourikwa	Western Cape	Gas	746
Renewables				
	Sere	Vredenburg	Wind	100
	Colley Wobbles	Mbashe River	Hydro	42
	First Falls	Umtata River	Hydro	6
	Ncora	Ncora River	Hydro	2
	Second Falls	Umtata River	Hydro	11

Notes

1. In 1995 alone the utility connected more than 300,000 households. See Fin24.com, 23 Feb 2019; https://www.fin24.com/Economy/1922-2019-the-rise-and-fall-of-eskom-20190213.
2. Indeed, in 2001 Eskom won the *Financial Times* Global Power Company of the Year Award for its technical excellence in plant production, maintenance and operation (University of Cape Town, 2013).
3. Bloomberg, 31 July 2019. https://www.washingtonpost.com/business/energy/why-eskoms-power-crisis-is-south-africas-top-risk/2019/07/31/7a146cb4-b366-11e9-acc8-1d847bacca73_story.html.
4. *The South African*, 2 Feb 2019. https://www.thesouthafrican.com/news/eskom-how-much-money-does-load-shedding-cost-south-africa/.
5. Power, 1 Feb 2019. https://www.powermag.com/the-big-picture-worlds-biggest-power-companies/.
6. Nalbandian-Sugden, 2016.
7. Eskom, 2019a; DPE, 2019.
8. Deloitte, 2017.
9. Out of a total nominal capacity of 44,172 MW in 2018/19, coal-fired stations accounted for 36,479 MW (82.6%), gas-fired stations 2,409 MW (5.5%), nuclear 1,860 MW (4.2%), hydro 600 MW (1.4%), pumped-storage 2,724 MW (6.2 %) and wind 100 MW (.2%).
10. Eskom, 2013.
11. Camden Ermelo (1510 MW), Grootvlei (Balfour, 1200 MW), and Komati (Middelburg, 940 MW).
12. Medupi (Lephalale, 4764 MW) and Kusile (Mpumalanga, 4800 MW).
13. Drakensberg, Palmiet, and Ingula.
14. Acacia and Palmiet.
15. Ankerlig and Gourikwa.
16. Wright and van Coller, 2018.
17. Mbendi *Information for Africa* (2005). South Africa: Electrical Power.
18. Bloomberg News. 2019. ' Zambia to import electricity from Eskom to plug severe deficit'. https://www.fin24.com/Economy/Eskom/zambia-to-import-electricity-from-eskom-to-plug-severe-deficit-20190924.
19. Van Harmelen G and R. Surtees (2003). 'Internet based energy trading in southern Africa'. AMEU 58th Convention.
20. National Electricity Regulator (2003). Electricity Supply Statistics for South Africa. Pretoria.
21. Eskom, 2019a.
22. Households are approximately 19%, commercial and government services around 15%, agriculture 3% and transportation a further 2% (Mokveld and von Eije, 2018).
23. Production of 143.2 mtoe (million tonnes oil equivalent) and consumption of 86.0 mtoe, according to BP, 2019.
24. Approximately a quarter of South Africa's bituminous coal is in depths between 15–50 m below the surface. Much of the remainder is between 50 and 200 m. Around half of the reserves are in seams of 4–6 m thickness and another third in 2–4 m seams. Approximately half of production comes from opencast mines, and the balance from underground mines (Eberhard, 2011).
25. In recent years, the reliability of the coal figures has been questioned. In 2004, the DME initiated a study to assess the country's true reserves. Energy Research Centre (University of Cape Town). 2004. *Energy for Sustainable Development: South African Profile*. Phase 1 final report.
26. Creamer Media's *Engineering News*. 2005/06/29.
27. Department of Energy, 2018.
28. Newbery and Eberhard, 2008.
29. This shift away from oil was also motivated by the increasing isolation of the government of South Africa and the economic sanctions that were imposed by the international community in retaliation to apartheid.
30. University of Cape Town, 2013.
31. Steyn, 2001.
32. Wolak, 2000.
33. Cassim et al., 2004.

34. Deloitte, 2017.

35. OECD, 2013.

36. Booz & Company, 2006.

37. In contrast, the Planned Capability Loss Factor (PCLF) is the percentage of energy lost due to planned shutdowns or load reductions under plant management control. Thus PCLF refers to generation capability lost due to planned maintenance that is performed during the expected down-time of a power generating unit for the purpose of routine maintenance.

38. Energy losses are considered unplanned if they are not scheduled at least four weeks in advance. A low value for this indicator implies that important plant equipment is reliably operated and well maintained.

39. The UCF is an inferred indicator, i.e. it is derived from the PCLF (Planned Capability Loss Factor) and the UCLF (Unplanned Capability Loss Factor). It is derived from the equation: UCF=100−PCLF−UCLF.

40. A high UCF indicates effective plant management programs and practices to minimise unplanned energy losses and to optimise planned outages, maximising available electrical generation.

41. Unplanned automatic grid separations (UAGS) per 7000 operating hours is an indicator measuring how often a generator is separated from the external grid, in both an unplanned and automatic (manual actions are excluded) manner; it is given as a rate per 7000 operating hours, thereby taking into account the wide variety of operating regimes.

42. Eskom. 2005. *Annual Report*.

43. Parliament, 2017.

44. Energy Availability Factor is the ratio of the available energy generation over a given time period to the maximum amount of energy which could be produced over the same time period. The EAF is an inferred indicator, i.e. it is derived from the PCLF which is the Planned Capability Loss Factor (maintenance in %), the UCLF (Unplanned Capability Loss Factor) and the OCLF (Other Capability Loss Factor) which are the random percentage losses, the latter being out of management control. The EAF effectively measures plant availability and takes into account energy losses not under control of plant management, as well as internal non- engineering constraints. It is determined for each period as shown below:

$$EAF\ (\%) = 100 \times (REG - PEL - UEL - XEL) / REG$$

Where:
REG = reference energy generation for the period
PEL = total planned energy losses
UEL = total unplanned energy loss
XEL = total external energy losses (beyond the plant management control).

45. Eskom, 2019.

46. Matona, 2014.

47. The decision by the cabinet to prohibit any new build by Eskom was described by Eberhard (2007) as South Africa's 'self-imposed' structural adjustment program in the context of the government's larger effort to improve the efficiencies of state-owned entities.

48. President Mbeki admitted in late in 2007: 'When Eskom said to the government, 'We think we must invest more in terms of electricity generation' We said, 'Not now, later'. We were wrong. Eskom was right. We were wrong'. Reuters, 20 March 2015. https://www.reuters.com/article/safrica-eskom/what-now-for-junk-rated-dinosaur-eskom-south-africa-asks-idUSL5N0VK2E420150320.

49. Baker, 2017.

50. Around 200 MW as of 2010, in contrast to the Eskom's planned build of more than 10,000 MW. See Eberhard and Pickering, 2010.

51. Eberhard and Godinho, 2017.

52. OECD, 2016.

53. Ironically, Eskom was the world's 'Utility of the Year' in 2001.

54. Jaglin and Dubresson, 2016.

55. *Creamer Media's Mining Weekly*, 26th February 2019. http://www.miningweekly.com/article/eskom-employees-were-pressured-to-sign-r43bn-contract-with-tegeta-zondo-inquiry-hears-2019-02-26.

56. Myburgh, 2017.

57. Matona, 2014.

58. Eberhard and Godinho, 2017.
59. BusinessDay, 26 April 2017. GE claims Eskom favoured Chinese firm's bid, with backing of Trillian. https://www.businesslive.co.za/bd/companies/energy/2017-04-26-ge-claims-eskom-favoured-trillion-bid/.
60. Eskom, 2019a.
61. Styan, 2015; Lawrence, 2020.
62. Parliament, 2018.
63. Deloitte, 2017.
64. IMF, 2013.
65. de Vos, 2019.
66. Fin24.com, 14 December 2016. 'IMF points to Eskom/IPP "Equal footing" as key to cut costs'. https://www.fin24.com/Economy/Eskom/imf-points-to-eskomipp-equal-footing-as-key-to-bringing-costs-down-20161214.
67. Boulle, 2019; Muller, 2019.
68. Brennan 1995; Klass and Salinger 1995.
69. Newbery 2001.
70. Newbery, 2018.
71. UN, 2018.
72. Wirth, 2020.
73. CSIR and Fraunhofer, 2016.
74. Joskow, 2010.
75. Cochran et al., 2015.
76. Bird et al., 2013.
77. Fin24.com, Feb 01 2020. 'From unbundling to self-restructuring: How the plan to make Eskom better changed'. https://www.fin24.com/Economy/Eskom/from-unbundling-to-self-restructuring-how-the-plan-to-make-eskom-better-changed-20200201-2.
78. Reuters, November 1, 2019. Moody's changes outlook on S. African sovereign rating to 'negative'. https://www.reuters.com/article/safrica-economy-ratings/moodys-changes-outlook-on-s-african-sovereign-rating-to-negative-idUSL8N27H627.
79. For example the analysis of boundaries, ownership, asset valuation, regulation, and human resources of the distribution industry undertaken by a consortium led by Price WaterhouseCoopers (PwC).
80. For example, the Electricity Distribution Industry Restructuring Committee (EDIRC).
81. Eberhard, A. 2005. 'From state to market and back again: South Africa's power sector reforms'. *Economic and Political Weekly*: 5309–17.
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83. Eskom 2019.
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