SRF SOCIAL RESEARCH FOUNDATION

JUNE 2023
REPORT 24/2023

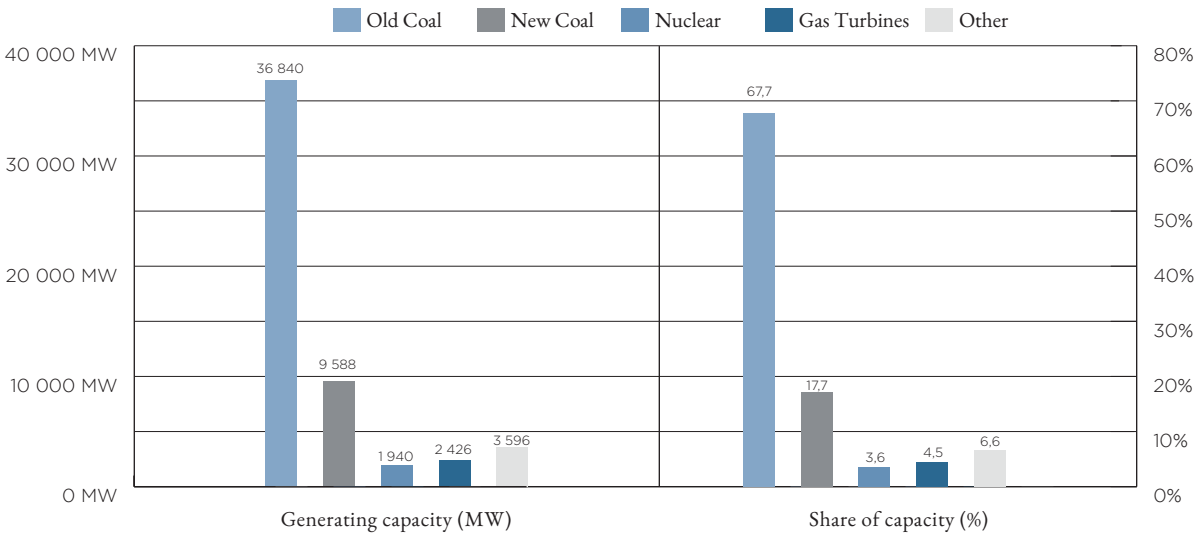
SOUTH AFRICA'S ELECTRICITY POSITION AND A ROUTE TO ITS RESOLUTION

This report provides an assessment of the electricity position in South Africa and proposes a route first to resolving the current loadshedding crisis and then to putting the country on an energy track capable of sustaining economic growth rates of 5% of GDP.

The report concludes that both objectives can be met within 12 and 60 month timeframes respectively. The data in the report is drawn from a host of official sources ranging from the South African electricity parastatal Eskom, to the national treasury, South Africa's official statistical agency, South African tax authorities as well as various private analysts and correspondences with knowledgeable individuals.

The chart below is a rough estimate, measured in megawatts (MW), of the bulk of the electricity generation resources that Eskom could in theory bring to bear on South Africa's electricity problem. In total Eskom controls roughly 55 000 MW of generating capacity. Roughly 46 000 MW, or 85% of that capacity, rests in new (the Medupi and Kusile plants) and old coal-fired power stations with the balance split between nuclear (just over 3%), gas turbines (that generally burn diesel in South Africa) at just over 4%, and other sources (mainly hydro and pumped storage and a little bit of wind and solar) making up just under 7% of potential generating capacity.

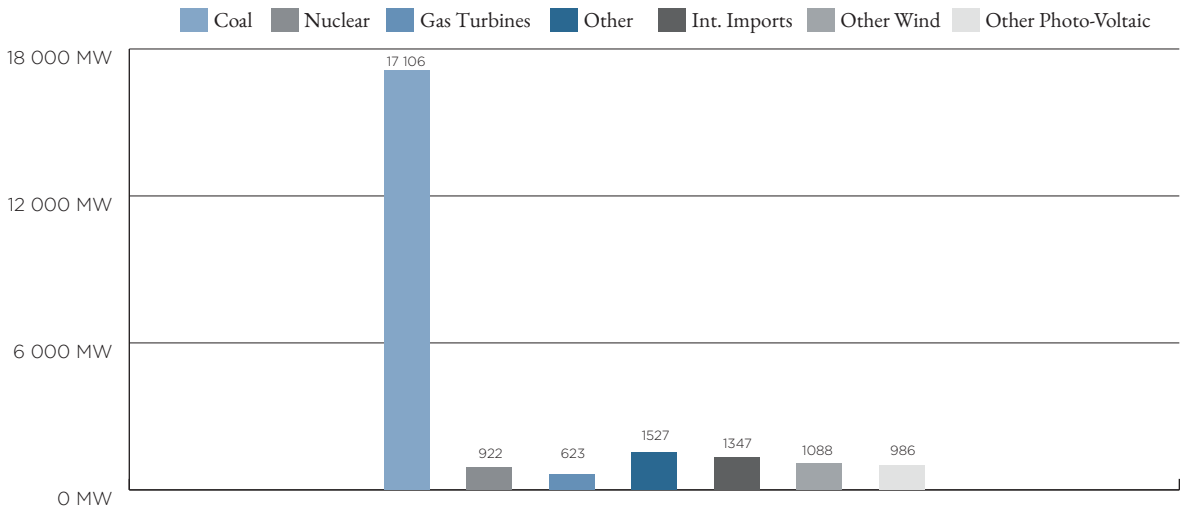
Eskom generating capacity by source
(MW and as a share of capacity)



This potential generating capacity must be compared to what is actually delivered into the grid.

The table below was drafted in February of 2023 as an average of what electricity was being generated, per hour, in one select week of that month. The data shows that around 17 000 MW of coal energy was produced. This amounted to just over a third (around 36%) of Eskom's potential coal capacity. Nuclear was operating at roughly 50% of potential (due to a refit of the Koeberg station), gas turbines were operating at roughly a quarter of potential (due to diesel shortages and cost constraints), whilst the 'other' category operated at around two-thirds of its potential. In addition there were international imports of around 1 300 MW and around a further 2 000 MW of additional wind and solar.

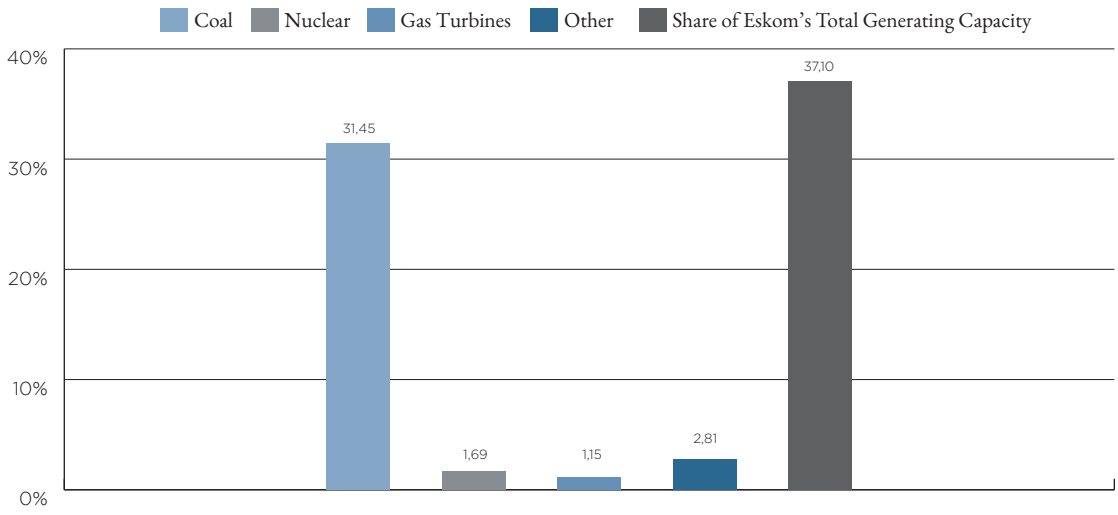
Hourly average of electricity generated by source in a select week of February 2023 (MW)



When the production numbers in the table above are added together the total comes just over 23 000 MW with Eskom infrastructure contributing roughly 20 000 of that.

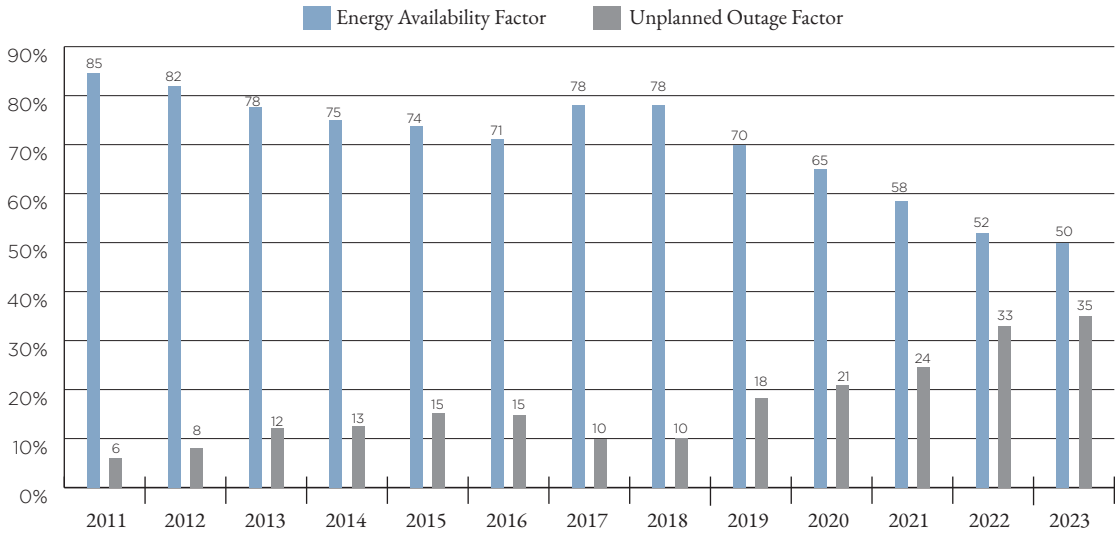
The table below, which measures Eskom generation figures by individual source as a share of total Eskom generation capacity, shows that the 20 000 figure means that Eskom power plants operated at roughly 37% of their 54 390 MW potential.

Eskom generation levels by individual source as a share of total Eskom production capacity and total production as a share of that capacity (%)



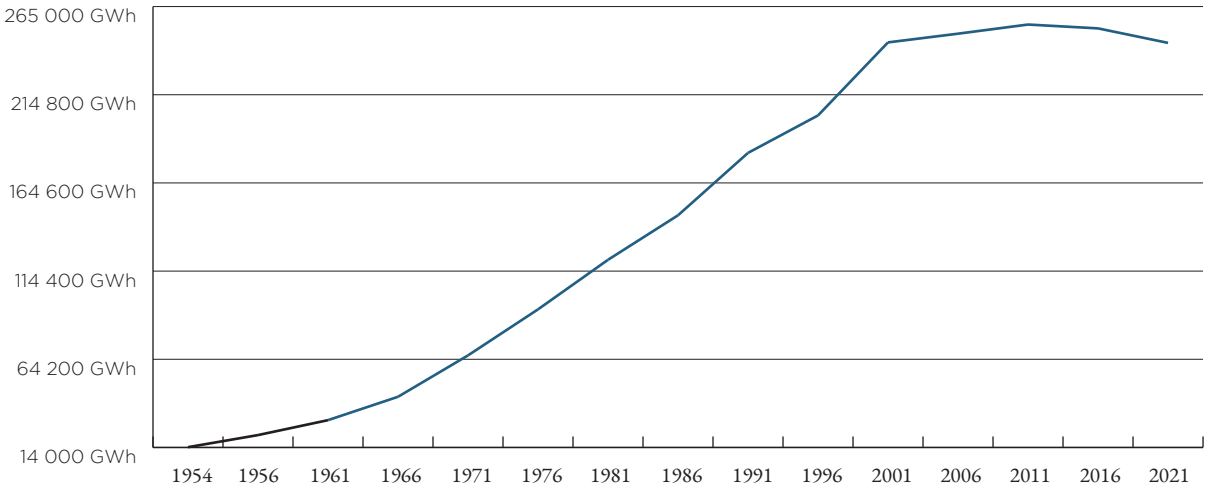
Eskom's production data is shown on the chart below in the form of a number it calls the Energy Availability Factor (EAF). Eskom currently reports this number at around 50% (for technical reasons that will not be addressed in this report that number is not comparable to the 37% figure cited above as the bases of the calculations behind these numbers differ although these definitional differences are of little significance to the Foundation's overall conclusions). What is significant however, and something upon which the Foundation's later advice will partly turn, is that the chart demonstrates just how quickly the Eskom EAF number has fallen from over 80%, just a decade or so ago, to the present near 50%. The chart shows that much of the reason for the fall relates to unplanned breakdowns at power plants or what Eskom calls the 'Unplanned Outage Factor'.

Eskom's Energy Availability Factor and Unplanned Outage Factor from 2011-2023



Related to the trends in the chart above is the question of total electricity production in South Africa over time. The chart below shows production in GWh over the past 70 years. To get a sense of scale consider that 1 000 KW equals a MW (a suburban home could run quite comfortably on a 5KW solar system), 1 000 MW equals a GW (a vast coal or nuclear station might produce 4GW), and if a GW of electricity is produced for one hour that would equal one GWh. The chart shows that production measured in GWh increased sharply through the 1990s to peak in the period 2008 to 2011 and that it has subsequently declined, in line with the falling EAF (and its underpinning indicator of plant breakdowns). Note from the chart how quickly energy demand lifted as economic growth lifted between roughly the end of the Asian financial crisis in 1998 to the period around 2008. That era was in some respects a relative golden age for South Africa's economy as economic growth lifted from 3% to reach 4% and then averaged 5% between 2004 and 2007 – the first time that had happened for four consecutive years since the first half of the 1960s.

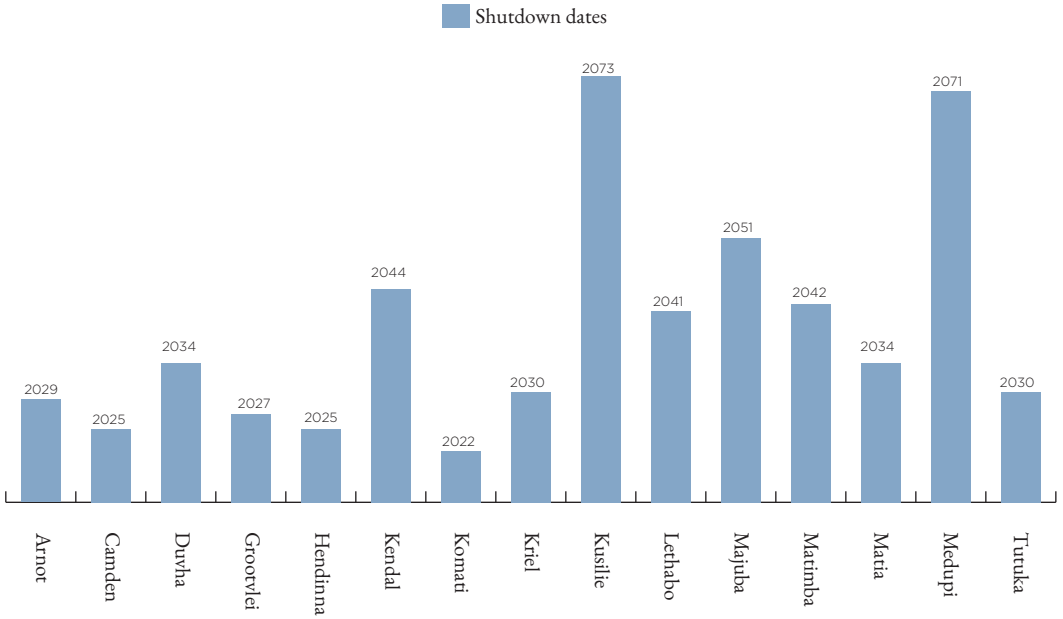
Estimated total electricity generation for South Africa 1954-2021 (GWh)



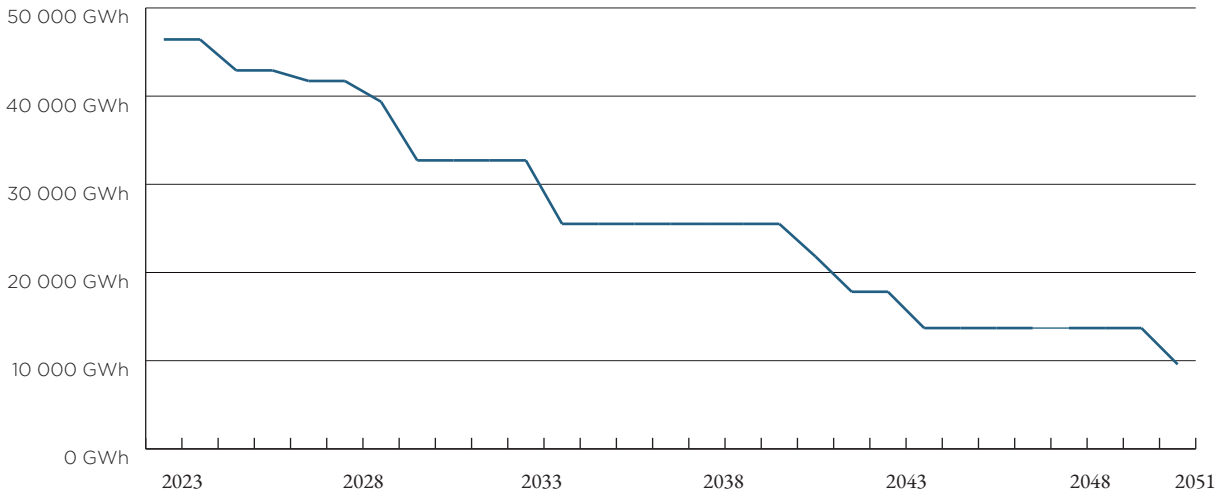
Of great concern is that despite the declining generation trend of the past decade both Eskom and the South African government have toyed with the idea of shutting down a significant proportion of the current coal-fired power fleet over the next several decades.

The table immediately below shows in alphabetical order the planned shutdown dates for Eskom's coal fleet. The table below that shows the quantum of coal-generated electricity remaining by 2051 if the initial dates to that point are met.

South Africa's proposed coal-fired power station shutdown dates 2029-2073

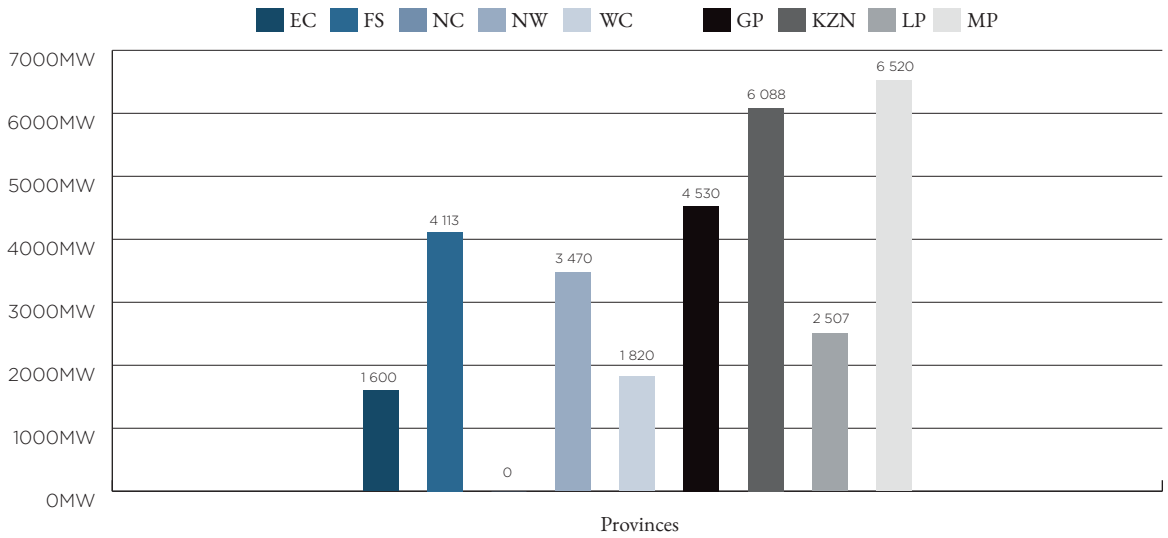


Remaining coal generating capacity by 2051 if proposed shutdown dates to that year are met



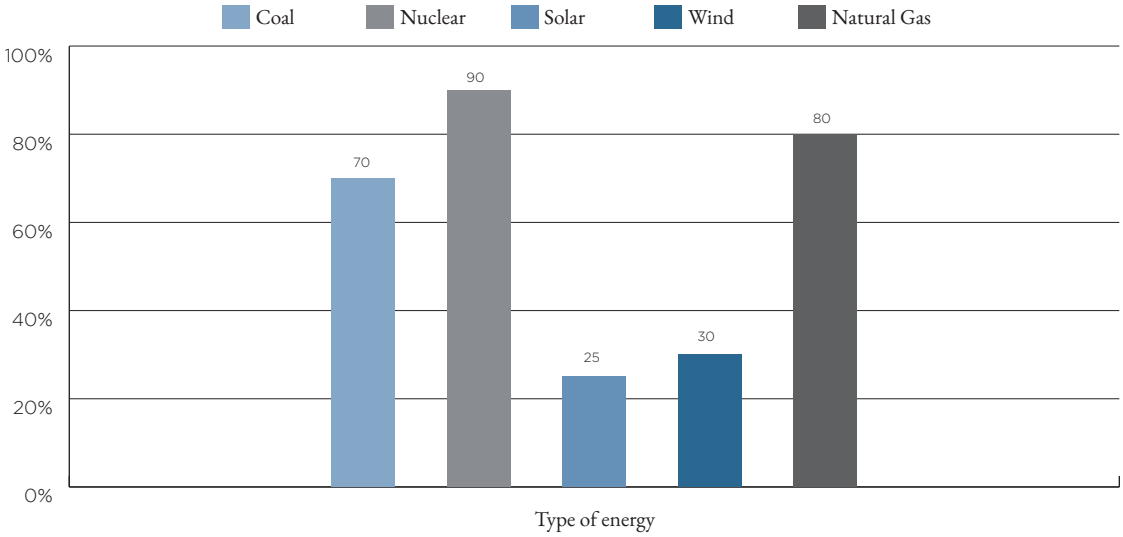
The intention is that the capacity lost as a consequence of coal plant shutdowns will be replaced via just energy transition projects ranging from solar and wind farms to pumped storage stations, battery storage and a host of related projects. One of the problems those projects will run into relates to transmission line capacity. The table below is a Foundation estimate that indicates the amount of space available on the country's transmission lines for new energy projects. There is considerable space running in a band North to South (a function of infrastructure designed for the country's now fading coal fleet). However, there is a very limited capacity running West to East meaning that the prospects for building solar plants in the arid Western regions of the country, where solar radiation levels are the highest, and transmitting that electricity into the central economic heartlands is limited and would necessitate the building of new grid capacity.

Surplus grid capacity in South Africa by province (MW)



In addition there is the question of capacity factors. These are indicators that measure the efficiency of a power plant. For example, if a power plant produced power 100% of the time to the maximum of its installed capacity it would have a capacity factor of 100%. Nuclear energy has a capacity factor of around 90%. Well maintained coal plants have a factor of around 70%. Wind has a factor of around 30% (depending on the geography etc) whilst solar has a factor of around 25%. What that means is that for solar plants to compete with coal plants the solar plants need to be built to roughly three times the scale of a coal plant. In addition solar and wind plants do not produce electricity in a consistent manner for two reasons. The first is that environmental conditions (sun and wind) are continually changing. The second is that the surplus energy they produce when conditions are favorable cannot be stored in a cost-effective manner. As storage technologies advance over the next several decades the competitiveness of wind and solar energy will too, but until that point is reached these technologies are not competitive alternatives to the dispatchability of coal and nuclear power that can be tapped on demand.

Average capacity factors of different types of electricity plants (%)



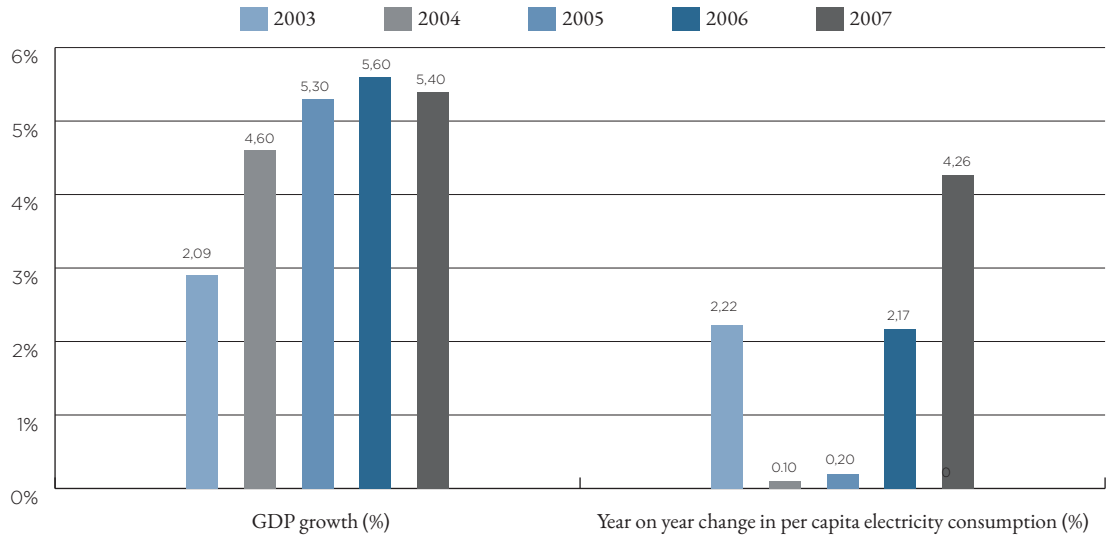
Smaller scale solar and wind projects will, however, play a disproportionality useful role in shoring up South Africa's economy given the country's peculiar advantage in being a fundamentally unequal society, with a very small tax base, in an economy that has over the past five decades become increasingly skewed towards service-oriented industries. The advantage is that much of South Africa's relatively small economic elite can to an extent mitigate the consequences of Eskom's failures by resorting to rooftop solar technology. The financial math on this works relatively well given that more prosperous households and profitable businesses that move to small-scale solar generation can employ the amounts they were previously paying to Eskom to instead service the loans they incur to install private solar systems.

As a baseline number from which to develop some understanding of this potential the Foundation has calculated that assuming 50% of individuals with earnings of over R750 000 per annum procure 5 KW household solar systems (with the critically important battery storage components included) almost a GW of capacity could be added to the economy (a GW is equivalent to one stage of loadshedding). Readers can manipulate the 50% figure and the 5 KW figure to get higher or lower numbers. We estimate that small businesses could add at least the same quantum of electricity whilst a trend of larger companies resorting to self-generation (and storage) will also become prevalent (there are already industrial producers with advanced plans to do this).

Understanding the scale of future electricity generation that will need to be achieved in order to again put South Africa in reach of high rates of economic growth requires some sort of baseline number around which the relationship between electricity production and economic growth can be estimated. Such estimates could vary greatly, of course, depending on the source of that growth and whether it is more industrially or service economy oriented, with the latter requiring less megawatts to generate each point of GDP expansion. Technology, price, and energy efficiency also plays a role and globally such efficiencies have increased sharply over time. To get to a baseline number to anchor some sort of analysis around, the Foundation calculated the year-on-year change in energy consumption for both high growth and low growth eras of South Africa's recent past.

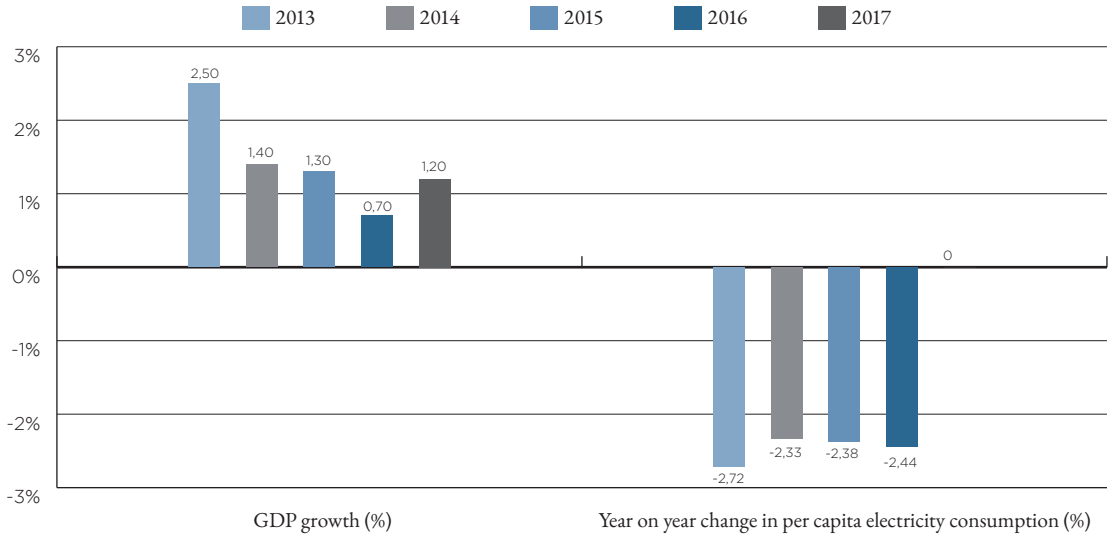
For example, the table below compares economic growth to the year-on-year change in electricity consumption for the period 2003 to 2007. This was a relatively high growth period for South Africa's economy. Economic growth averaged 4,76% whilst electricity consumption increased by 1,79% per annum.

GDP growth compared to the y/y change in electricity consumption 2003-2007 (%)



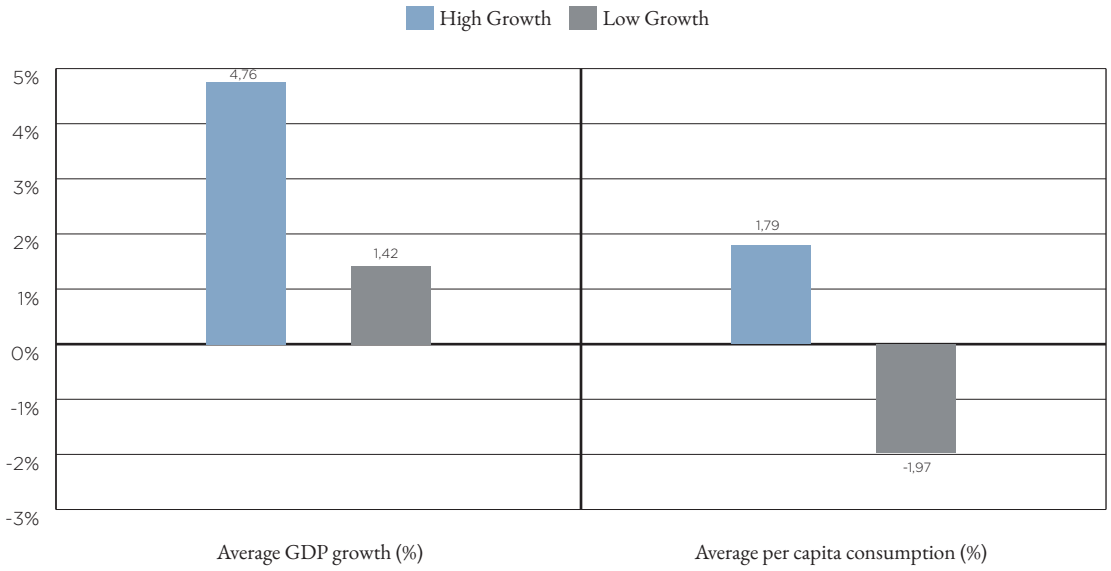
The above table can be compared to that below for the relatively low economic growth era of 2013 to 2017. Over this era economic growth averaged 1,42% whilst electricity consumption declined by 1,97% per annum.

GDP growth compared to the y/y change in electricity consumption 2013-2017



The table below compares the averages of both eras.

Average GDP growth compared to the y/y change in per capita electricity consumption for the relatively high growth 2003-2007 era and the relatively low growth 2013-2017 era (%)



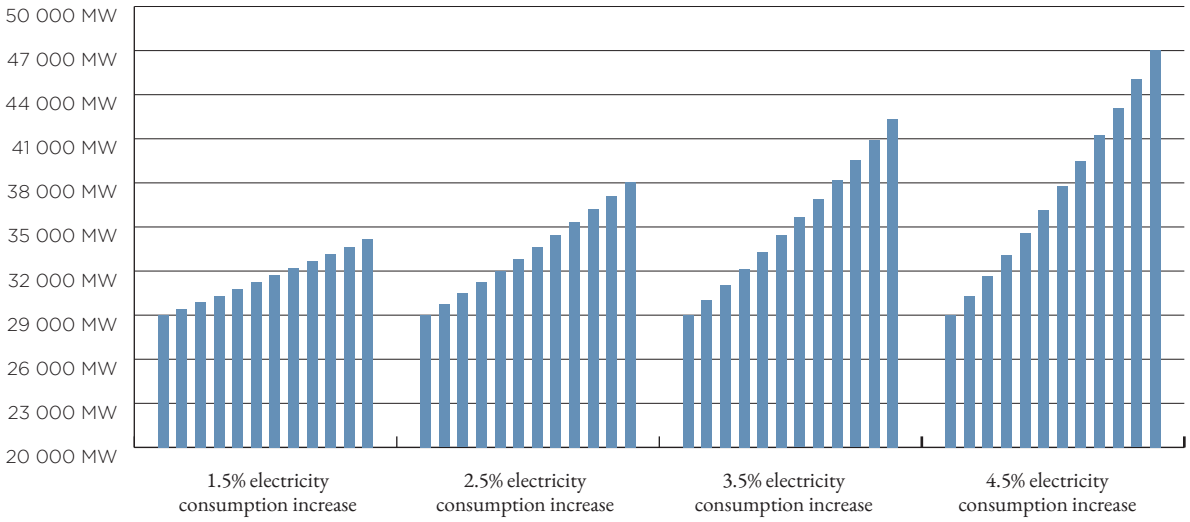
From these and other assessments, and taking into account the structure of South Africa's economy and its skills base, we judge that each additional future point of annual GDP growth pay require in the region of a half point rise in electricity consumption (later below we also demonstrate the implications of lower and higher rises in electricity consumption per point of GDP growth).

Next it is necessary to understand the relationship between living standards and economic growth in order to estimate what levels of growth need to be secured in order to liberate the millions of poor and unemployed South Africans from a life of desperation and poverty. Fortunately the relationship between economic growth and living standards is fairly well established and the latter has pretty consistently correlated to the former over the past 25 years. The only era of that 25 year period that saw a sharp fall in the unemployment rate was between roughly 2000 and 2008 when the rate of unemployment fell from nearly 30% to nearer 20% as economic growth rose through the 3% and 4% levels to average 5% towards the end of that period. That rate of growth further financed much more successful service delivery efforts than the government was ever credited with as well as the rollout of an expansive welfare program even as government debt levels were halved and a budget surplus was briefly recorded. A standing Foundation estimate is that South Africa needs to aspire to a growth rate of around 5% of GDP in order to make serious inroads to the unemployment rate and free the state to invest more generously in social protection and upliftment projects.

Having weighed up the evidence as best as possible in order to put a number on the table we judge that South Africa will need to plan (from a baseline of zero loadshedding) to up its annual electricity consumption rates by around 2.5% per annum if it is again to aspire to an economic growth rate approaching 5% of GDP.

In the table below we set out the implications (together with higher and lower consumption rises to provide some broader perspective). The table sets out 10 future years for South Africa from a zero loadshedding baseline (meaning that a further 4 000 MW to 6 000 MW must first be added to grid to bring loadshedding comfortably to stage zero, even before this future analysis can begin). The table shows that if the estimate of 2.5% electricity consumption growth is in the ballpark then over those ten years generation would need to rise from around 29 000 MW to nearer 38 000 MW. Also included on the chart are estimates of electricity consumption growth increasing at 1.5%, 3.5% and 4.5% per annum for the benefit of readers who wish to understand the implications of electricity consumption rates of increase rising at lower or higher levels than our 2.5% baseline estimate.

Various year on year rates of electricity consumption increases necessary to enable economic growth rates approaching 5% of GDP (MW)



Is any of this achievable? It very easily is. To demonstrate that we take a 12 month, 60 month, and 240 month view.

The recent position has been that in the region of 23 000 MW are produced on any given day. This translates into loadshedding stages four to six with each stage being equivalent to 1000 MW. To reduce that to stage zero a further 4 000 MW to 6 000 MW need to be found. Fortunately this is not difficult. For example:

- When the Koeberg station is again fully operational a stage of load shedding will be eliminated.
- By running gas turbines at their maximum potential, and maybe adding a turbine, a further two stages might be done away with.
- By improving the capacity of the broader coal fleet by just 5% (by procuring quality coal and lifting basic maintenance standards) a further two stages could be eliminated.
- Private household and small business provision could eliminate a further two stages.
- Getting environmental permission to bypass some emissions safeguards could eliminate a further two stages.

Already that would amount to nine stages of load shedding being eliminated and there are various mathematical formulations that get back to the same conclusion, that it is perfectly feasible that loadshedding could be reduced to stage zero within 12 months.

On the 60 month view a project could be undertaken to overhaul a third of the coal fleet as follows:

- That fleet has an installed capacity of around 45 000 MW but is producing just a third of that at around 17 000 MW.
- The overhaul would target a cumulative 15 000 MW of coal plants and involve auditing defunct coal plants or those entering the end of their productive life spans, refitting those components that are worn or failing, and bringing those plants back into production.
- Such a refit should take between three and five years and culminate in adding between roughly 10 500 MW and 12 000 MW to the grid over the next 60 months, assuming capacity factors of between 70% and 80%, which would culminate in total production numbers in the region of 40 000 MW by the end of this decade, in line therefore with the number estimated as necessary to again enable growth rates of over 5% of GDP.

This outcome does not require the building of any new power stations, can be financed by the South African government and private investors, and does not require additional grid capacity. Bear in mind that this estimate does not account for any large scale solar and wind investments that may add a further, admittedly erratic, 2 000 MW to 3 000 MW to the grid over the next decade (assuming that 10 000 MW of private green energy is, in fact, installed).

On the 240 month view the advice is to commence a nuclear build capable of replacing the refurbished coal fleet (we estimate in the region of 40 000 MW of nuclear if South Africa is to succeed as a highly competitive emerging market) as this comes to the end of its life and complementing that build with vast private renewables investment, although technological advancement, especially in relation to storage technologies, may over time be sufficient for the renewable component to eat into the extent of the required nuclear build.

TENTATIVE CONCLUSIONS

The 12, 60, 240 monthly strategy would therefore be perfectly consistent with South Africa's just transition ambitions culminating within 20 years in an economy fueled by clean technology and the strategy proposed here does not therefore amount to locking South Africa into a coal dependent future. It is counterintuitive that reaching South Africa's clean ambitions must commence with new investment into hydrocarbons but the present energy position is so dire, and its socio-economic consequences so harsh, that failing that there may not be a competitive economy and related democracy that cares very much about things such as 'just transitions' 20 years from now.

This report was produced by the Social Research Foundation, a think-tank focusing on public policy issues and the promotion of democracy.

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