The Benefits and Challenges Associated With Coal in South Africa

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The important role that coal has played in South Africa’s economic development is often downplayed in today’s world, where fossil fuels are frequently denigrated. Coal supplies over 70% of the country’s energy needs, over 90% of its electricity requirements, and over 95% of its metallurgical carbon (coke) requirements. While these percentages are likely to decline in the long run, they are likely to remain significant over the next 30 years, failing which serious long-term damage to the economy could result.

Coal was South Africa’s primary source of resource revenue for total sales value in 2011, 2012, and 2013 (Figure 1) and the first commodity to generate a total sales value in excess of R100 billion (US$9.3 billion) in one year.¹⁻³ Such statistics highlight the continuing importance of coal to the South African economy.

THE CORNERSTONE OF SOUTH AFRICAN ENERGY

The Electric Sector

Eskom is the state-owned utility charged with providing the country and greater region with power. Thirteen coal-fired power stations are currently in operation, including three that were recommissioned after being mothballed. All but three stations use pulverized fuel technologies.⁴⁻⁵

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Eskom relies on coal-fired power stations to produce approximately 90% of its electricity. These stations operate 24 hours a day to meet demand. Eskom’s Generation Division provides an installed capacity of 37,745 MW from the 13 coal-fired power stations. Their total net output, excluding the power consumed by their auxiliaries and generators currently in reserve storage, is 34,952 MW. Two new coal-fired power stations,
Medupi and Kusile (similar supercritical coal-fired power stations with a planned efficiency of 38% compared to 34% of the subcritical technologies in the older stations), are now under construction and are proceeding in accordance with environmental requirements from funders and legislation.

The Integrated Resources Plan for Electricity (IRP) envisages a further 6250 MW of new coal being required before 2030. We believe this will be totally inadequate if South Africa is to achieve higher rates of economic and industrial growth. The IRP envisages 9600 MW of new nuclear power. We are concerned that there will be fairly substantial delays in bringing nuclear power on line by 2023, given that the normally accepted lead time for nuclear power is 14 years. This could mean the new nuclear power may not come online until 2029 at the earliest.

Coal would be a more reliable and lower-cost baseload option for the time frames under consideration. The capital cost for coal-fired power stations, in particular, is substantially less than for nuclear power stations. We believe that the higher capital costs may well have compromised South Africa’s sovereign ratings and, therefore, its ability to fund other essential infrastructure and social development programs. Although nuclear power should not be excluded, a smaller nuclear allocation would be a more prudent solution. Thus, we recommend that at least 8 GW of new coal capacity is required if South Africa is to achieve the higher levels of economic growth required by the National Development Plan. The fact is that energy, electricity, and employment growth are the keys to South Africa’s future economic, social, and political prosperity, sustainability, and stability. Ensuring the security of supply of energy sources for electricity at competitive prices is a prerequisite for this to occur. Fossil fuels—in the form of gas and coal in South Africa’s case—are the only sources of local energy that can provide sufficient security of baseload electricity supply for this to be a realistic, achievable goal.

The Cost and Coal Cliffs

A key national decision after the Second World War was that South Africa’s industrial development should be based on inexpensive energy to promote growth. Given the resources available, coal-based energy became the central driving force behind the modern economic state of South Africa.

However, today’s energy prices are skyrocketing. Eskom’s tariff has more than tripled from R20 c/kWh in 2003 to >R70 c/kWh in 2014 [compared with an average price of R212 c/kWh for Independent Power Producers (IPP) in 2013]. This is a result of the influence of the ruling party during the late 1990s when Eskom’s proposal to build further coal-fired power stations due to diminishing spare capacity was rejected in favor of IPPs which ultimately did not materialize, the current indecision regarding the way forward, and the World Bank’s lending terms. The estimated cost of power from both Medupi and Kusile is expected to be about R1.00/kWh. In addition, the price is expected to double in the next five years. Known as the cost cliff, this is further exacerbated by the fact that most municipalities charge a 100% markup. This is caused by a multitude of factors, ranging from increases in the cost for coal and new-build power plants to policy measures, and means that homes and offices now pay ~R140 c/kWh, for example, in Gauteng.

Looking to the future, South Africa is facing a dramatic power crisis largely caused by the lack of sufficient coal for power generation over the next five years. Known as the looming coal cliff, the size of the coal shortfall ranges from 60 to 120 Mt and is expected to impact the country between 2014 and 2019. South Africa’s biggest near-term energy challenge, therefore, is to supply Eskom over the next five years. Of the four billion tons of coal that Eskom will need over the next 40 years, two billion tons will need to come from new sources.

Sasol and CTL

In South Africa, Sasol has been producing fuels and chemicals using Fischer–Tropsch technology since 1955 and has evolved into one of the country’s largest corporate contributors to economic development. Sasol contributes about R40 billion, or 4%, to South Africa’s national annual gross domestic product (GDP). Sasol supplies about 25% of the country’s liquid fuel needs through synfuels derived from coal and natural gas at Secunda, and an additional 12% from conventional fuels derived from crude-oil refining via their Natref oil refinery at Sasolburg. This saves the country more than R30 billion a year in foreign exchange as a result of not having to import finished fuels.
liquid petroleum product, chemical feedstock, intermediates, and final products.

SOUTH AFRICA’S ENERGY RESERVES

South Africa possesses an abundant supply of most key economically important minerals, with the key exception of crude oil. Natural gas on the Cape South and West coasts and the potential of the Karoo shale gas deposits could well resolve South Africa’s energy problems for the next two or three generations. The largest energy resource is coal; the country is endowed with estimated coal reserves sufficient to cater for both domestic and export demand for 200 years with a sizeable reserve beginning to be exploited in the Waterberg in Limpopo Province and in the neighboring countries of Botswana, Zimbabwe, and Mozambique.

CHALLENGES

Coal has become to South Africa what oil is to the countries of the Middle East—the basis of its economy as the primary source of foreign exchange, energy, and its manufacturing industry. However, the future of coal in South Africa also faces many challenges, not the least of which is a lack of a clear strategy for the future. As the National Planning Commission (NPC) noted:

While most of South Africa’s energy comes from coal, it is striking that government has no integrated coal policy. South Africa ranks fifth internationally as a coal producer and exporter, yet government has no clear export strategy. There is also no integrated development of mining, rail and port infrastructure to facilitate either exports or anticipated increases in local production and consumption, within acceptable environmental constraints. The private shareholders of the Richards Bay Coal Terminal have expanded export capacity to 91 million tons per year. However, Transnet has barely been able to transport 60 million tons per year from the central coal fields to the coast. Government urgently needs to bring together all relevant players (mining companies, Transnet, Richards Bay Coal Terminal, relevant government departments, banks and others) to forge an agreed investment strategy and plan to accelerate coal exports, which could have beneficial balance of payment and current account impacts. An expanded export drive would need to be framed within a national policy on the optimal use of depleting coal reserves, including secure supplies for legacy power stations, and the opening of the Waterberg with the required rail links. The private sector has initiated work on a Coal Road Map. Government needs to be an active partner.

Although the current contribution of the coal value chain to the South African economy—in terms of employment, income, energy supply, and contribution to GDP, coupled with South Africa’s significant coal resources—demonstrates a strong potential for continued economic benefit and energy security, there are a number of challenges to the value chain that will shape its future. Not the least of these is efforts to mitigate climate change, which is increasingly shaping international energy debates.

Therefore, serious consideration must be given to the risks and weaknesses that are starting to threaten this mineral commodity, as well as to the potential strengths and opportunities that could arise from a new approach in the future.

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Several major concerns confront coal in South Africa. For instance, the run-of-mine coal qualities are now generally higher in ash content and therefore lower in grade as much of the better quality coals have already been selectively extracted. Coals on the thermal (steam) market in South Africa are sold on grade (i.e., calorific content). From the late 1970s well into the 1990s, South Africa mined out and sold very clean low-ash coals (known as Special Grade) to Asia as blend coking coals (7% ash) and moderately clean (10–14% ash) coal to Europe (high-grade steam coals or Grade A).

The top grades (Grades A to B) with ash contents of 15% or less (note that little such coal remains) are now either exported or sold at a premium domestically/export parity. Such coal products are few and far between today and often not economically profitable to produce from the high-ash materials now being mined. This means that over 80% of local coals sold to the inland market (including Eskom and Sasol) are now classified as Grades C and D, with average ash contents of 20–30%. India is also a purchaser of some of these grades for their Indian power stations (generally ash contents of 20–25%), leaving local users with even lower grades for home use. Eskom now burns coal averaging 35–45% ash contents in some of its more recently built power stations.

Beneficiation of the coals currently being mined is therefore mandatory in order to provide products suitable for local and
export market purposes; this is with the exception of Eskom because they have designed their power stations according to the available coal.

The shortage of water for beneficiation processes is also becoming a serious concern, especially in remote coalfields such as those north of the main Karoo Basin. This is a limiting factor in the chain of production. Dry coal beneficiation processes are now under serious investigation. Eskom aims to reduce freshwater usage and eliminate liquid effluent discharge through effective water management processes, water conservation and water-demand practices, as well as the treatment and potential use of mine water. The future key performance indicator targets progressively reduce to 1.20 L/kWh by 2017.

The production of ever-increasing tonnages of discard stockpiles arising from beneficiation is an ongoing point of concern for land owners and environmentalists. Currently over two billion tons are stored in stockpiles in various coal mining districts, with a further 60 million tons accumulating each year. Technological processes are being investigated to make use of this potentially useful carbon resource.

The coalfields of the future lying farther afield will require considerable infrastructure and development before such resources can be fully utilized. In turn, this is likely to incur increased costs not only for establishing new mines and supporting urban, retail, and industrialized areas, but also for transporting coal to the traditional areas of industrialization (Gauteng).

Logistics for the transport of coal to and from remote coalfields and from current coalfields to the Richards Bay Coal Terminal for export is constrained by railage limitations at present, thereby impeding the export capacity of South African coal to markets abroad. Road transport is currently damaging the surfaces of the roads in the northeastern sector of the country, a fact which is currently receiving considerable attention.

The threat of acid mine drainage from defunct mines remains an ever-present concern. Government is seeking solutions to these problems arising from the past and is imposing stringent regulations in the form of environmental impact assessments and mine closure insurances on currently operating mines.

The storage of CO\textsubscript{2}, the most abundant greenhouse gas produced predominantly from the power stations boilers and petrochemical gasifiers in this country, may be limited by a lack of underground storage capacity in South Africa. Currently identified sites are relatively far removed from point sources.

Environmental pressures are increasing and, notwithstanding the future potential benefits of carbon credits, carbon taxes are already making their first appearance. International trade partners appear to be considering the banning of exports from countries whose exporting manufacturers have unacceptably high carbon footprints. In a country such as South Africa, where power generation and petrochemical production give rise to high carbon emissions with little chance of commercially feasible CO\textsubscript{2}, such threats are of serious concern.

Notwithstanding the issues outlined above, the South African coal industry is buoyant and currently addressing the many issues that face the industry. Several of these issues can be addressed through the development and deployment of domestically derived clean-coal technologies that are being designed to specifically suit the needs in South Africa, including high-ash coal, low water availability, and socioeconomic requirements.

**CLEAN COAL TECHNOLOGIES**

Given the undeniable need to use coal as the baseload source of energy in South Africa, the country has been undertaking research in a number of clean coal technology areas, and in some fields South Africa can now be considered a global leader.

For instance, acid mine drainage research has shown that such water can be used for agriculture, with fly ash from power stations used as a filter in the upgrading/treatment process.

Beneficiation has been developed to an advanced, world-class degree, which provides cleaner coal that can improve plant efficiencies and reduce CO\textsubscript{2} emissions. A number of new dry coal beneficiating technologies are now undergoing pilot-scale testing in an attempt to reduce the requirement for water in such processes. The results to date have proved highly successful, with considerable beneficial impacts in user processes; for example, the upgrade (i.e., deshaling or the removal of contaminating rock) from the coals being sold to the Eskom power stations.

The upgrading and use of coal washery discard materials is undergoing further review as a source of energy in fluidized bed combustion and gasification processes. The ash from such processes is being developed for use in cement manufacture, and in building and road materials.

Furthermore, cleaner and more environmentally friendly processes, including underground coal gasification (UCG), are now being developed, with Eskom’s UCG pilot-scale initiative being considered a world-class feat. The process has been in use at the Majuba Colliery in KwaZulu-Natal for about three years and gas with calorific values averaging 4 MJ/L has been fed into the Majuba power station on a pilot-scale basis. Should this process continue to prove successful in larger-scale operation, this technique could make possible considerably cleaner in-seam utilization of the many deeper and poorer-grade coal seams in South and southern Africa.
The logistics of transport are under discussion in terms of privatizing railroad links and increasing rolling stock (i.e., rail wagons and locomotives). In addition, smaller mines are collaborating to share stockpiling and sidings in an attempt to rationalize road transport.

To increase efficiencies of coal utilization (i.e., using less coal for more power, thereby reducing greenhouse emissions), Eskom has set and achieved high targets in terms of increased combustion efficiencies in some of the world’s largest coal-fired power stations, some of which are using coals with ash contents well in excess of 45%—a feat not yet achieved anywhere else.

Increased boiler efficiencies in all other industrial coal-using plants to ensure considerably lower emissions of CO₂ are ongoing and the subject of current training and consultations.

In terms of criteria emissions, flue gas desulfurization (FGD) systems are being installed in some power plants, while smaller capture-ready units are readily available for others. However, given the low sulfur, mercury, arsenic, and chlorine contents of South African coals, control over these toxic emissions may not need to be as stringent as is the case in the coals of the Northern Hemisphere. Research conducted in South Africa on coals in the Highveld Coalfield has shown that sulfur reduction through beneficiation prior to use could be more cost-effective and efficient than through the installation of post-use FGD processes.

With regard to CO₂ emissions, research is currently being targeted at CO₂ utilization rather than storage. Long term, relatively advanced research is currently underway in South Africa to utilize CO₂ by developing algal and/or bamboo farms for CO₂ adsorption and biomass co-firing adjacent to power stations, coal-to-liquids plants, and agricultural land.

**CONCLUSIONS**

The future sustainability of energy in South Africa—whether based upon coal, nuclear, or renewables—will depend on the ability to fund it by the government of the day. The consumer, who ultimately foots the bill, will be the key factor in determining how the energy mix functions.

While many legislative, technical, and economic steps remain to be taken, and minds must be turned to achieving the goals of an environmentally “clean” South Africa, much has already been initiated. The future will depend on the vision of those yet to come, for the road is long and the plans of action are more than one generation in duration. One thing is certain, however: The value of coal as an energy source and a highly prized carbon-based chemical source can never be underestimated. Coal is undeniably the source of the most valuable commodity in the South African economy as it provides low-cost energy and is the source of some of the most valuable chemicals known to man.

**REFERENCES**


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