Report R76/2009

THE FUTURE ROLE OF THE WATERBERG COALFIELD IN SOUTH AFRICA'S COAL INDUSTRY

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1. INTRODUCTION

South Africa's indigenous energy resource base is dominated by coal. The bulk of South Africa's coal reserves are situated in the central basin, which consists of the Witbank, Highveld, Ermelo, South Rand and KwaZulu-Natal coalfields. The Witbank area of Mpumalanga contains extensive coal reserves and remains the country's most productive coalfield. Production from both Witbank and Highveld coalfields represents just over 80 percent of the total run-of-mine (ROM) coal in the country.

South Africa has an estimated 30 billion tons of proven coal reserves left, which, at current production rates, would only offer supply for the next 40 to 50 years. An estimated 27 percent of these reserves are located in the Witbank and Highveld coalfields. However, it has become more and more apparent that production from the Witbank-Highveld coalfields will be difficult to sustain in the not-so-distant future. It is believed that by 2020, reserves in many of the large coal mines in these coalfields will be near exhaustion, taking into account the fact that power generation demand is likely to continue rising. The uncertainty of the availability of significant amounts of economically extractable coal reserves for future use means that the generally expected dependence on the Witbank-Highveld coalfields well into the foreseeable future is also uncertain.

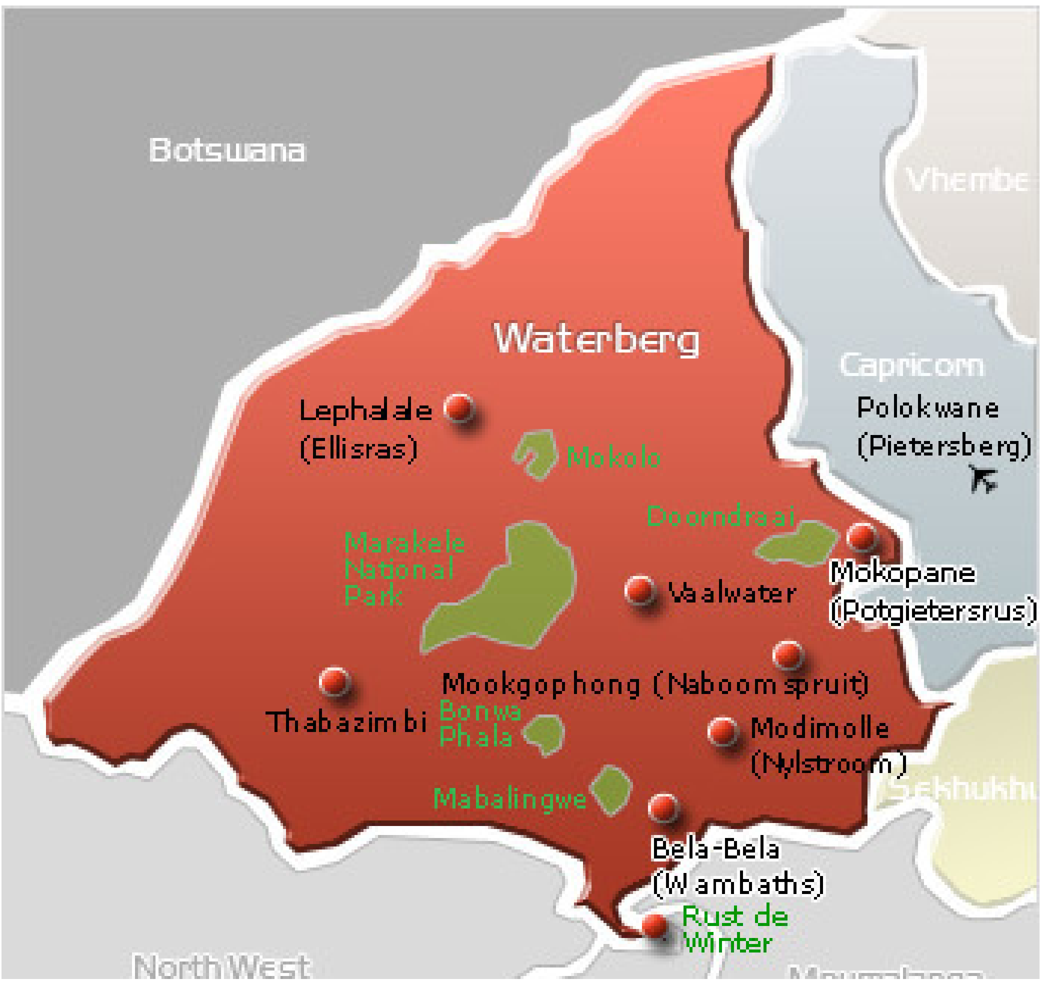
The Waterberg coalfield in the Limpopo Province has been largely untapped and as such could be regarded as SA's future, as far as coal is concerned. Hosting 40 percent of SA's remaining coal resources, the Waterberg coalfield offers a unique opportunity of significantly increasing the country's coal reserves and doubling its output through new discoveries and developments. This has led to considerable interest and activity in the region, with many new research projects and pilot scale developments. The main aim of this report is therefore to review developments and highlight the new approaches that are now being taken regarding the Waterberg Coalfield, for future coal and energy developments in South Africa.

2. GEOLOGY AND EXPLOITATION OF WATERBERG

2.1 Location and General Geology

Coal reserves in SA are hosted in sediments of the Permian age which overlie a large area of the country. The coalfields are generally spread over an area of 700 km from north to south and 500 km from east to west. The Waterberg Coalfield, located in the Waterberg basin, is situated in the north-western part of Limpopo province (Figure 1). It trends east-west and is characterised by faults, which strike east-west. Such faults are somewhat responsible for the deep occurrence of coal in some areas, which is the reason why those particular areas have been deemed unmineable. This is in contrast with the majority of South Africa's coal deposits, particularly in the Witbank-Highveld coalfields, which are relatively shallow with thick seams and are thus easier and usually cheaper to mine.

FIGURE 1: THE LOCATION OF THE WATERBERG COALFIELD.



The Waterberg Coalfield has a 75 billion tonnes resource, making up just over 40 percent of South Africa's total coal resources. Realistically, however, it will only be economically viable to convert a fraction of this resource into mineable reserves. The coalfield hosts coking coal as well as coal for power generation from both the Vryheid and Grootegeluk Formations of the Karoo Supergroup.

The Grootegeluk Formation consists of low grade coal with an ash content of up to 65 percent. Consequently, it has to be beneficiated to get low ash products such as blend coking coal (approximately 10 percent ash content) and middlings (maximum of 35 percent ash content) suitable for power generation. The high P_2O_5 content of up to 10 percent in the coal ash of the lower zones in the Grootegeluk Formation makes these zones unsuitable as a source of metallurgical coal. Characteristics of some coal products (air dry basis) from the Grootegeluk Formation are shown in Table 1.

TABLE 1: CHARACTERISTICS OF BENEFICIATED COAL PRODUCTS FROM THE GROOTEGELUK FORMATION.

	Blend Coking Coal*	Powerstation Coal (Middlings)*
Ash %	10,0	35,0 max
Volatile %	38,0 max	22,0 max
Moisture %	10,0 max	11,0 max
Sulphur %	1,1	1,4 max

* Characteristics are based on 12 – 14 percent and 23 – 26 percent yield on ROM for blend coking coal and power station coal, respectively.

On the other hand, raw coal from the Vryheid Formation is used as steam coal and for conversion into fuels and chemicals. A small percentage of the Vryheid Formation coal can be processed to higher quality metallurgical products and blend coking coal that can be considered for export.

2.2 Current Production

Exxaro's Grootegeluk opencast coal mine, the largest coal mine in SA, is the only operational mine currently situated in the Waterberg Coalfield (Figure 2). It was commissioned in 1980 to provide coking coal to the steel plants of the then Iscor. The mine also boasts the largest complex of coal beneficiation plants in the world, allowing it to produce a diversity of products. It is also South Africa's lowest cost coal mine on a free-on-rail basis and is the sole source of coal for Eskom's Matimba power station, the largest directly dry-cooled power station in the world.

FIGURE 2: OPERATIONS AT EXXARO'S GROOTEGELUK COAL MINE.

Currently, Exxaro mines several coal zones or coal mining benches in the Grootegeluk mine, which are grouped into two zones. The Upper Ecca zone (Grootegeluk Formation) is characterised by bright coal with interbedded shale, while the Middle Ecca zone (Vryheid Formation) comprises dull coal, sandstone and carbonaceous shale. The coal is generally rich in vitrinite content, thus making it suitable for direct liquefaction. In 2007 the Grootegeluk mine produced 18,5 Mt of coal, of which approximately 14,6 Mt was sold to Eskom and approximately 0,72 Mt was exported. The remaining 3,18 Mt was sold domestically to the metals and other industries.

Of all the remaining coal resources in the Waterberg, just over 60 percent would require underground mining, while the remaining portion can be mined in an opencast manner, depending on market trends and logistics. The majority of these resources occur in the Upper Ecca Grootegeluk Formation.

3. CURRENT AND FUTURE DVELOPMENTS

3.1 Expansion of Power Generation

Internationally, coal is the most widely used primary fuel, accounting for about 36 percent of the total fuel consumption of the world's electricity production. In South Africa, 183 Mt of coal was sold locally in 2007, with 61 percent being consumed in the electricity sector. It is estimated that electricity demand will grow at 1 200 MW per annum over the next 20 years. This would require at least 8 new power stations. However, most of Eskom's sources for coal are expected to be depleted in the next 15 years, posing an inevitable question of where all the coal is going to come from.

The ever growing energy demands, coupled with the depletion of coal reserves in other major coalfields, have led to several major developments being undertaken within the Waterberg area. One of the most significant developments is the expansion of power generation by building new power stations as well as expanding the existing 4 000 MW Matimba Power station, which already sources all its coal requirements from the Grootegeluk mine.

Exxaro has devised a three – phase development plan for the Waterberg. Phase 1 of the plan involves brown fields expansion of the current Grootegeluk coal mine to be able to supply Matimba power station with an extra 7.5 Mt between 2009 and 2015. The company has reached an agreement with Eskom to supply a total of 14,6 Mt/year of coal to the Medupi power station, which is now under construction adjacent Grootegeluk mine. In 10 – 12 years time, a new coal mine is expected to produce 10 Mt of coal, signalling Phase 3 of the development plan.

South Africa's dependence on coal for its elctricity needs is unlikely to change in the next two decades owing to the relative lack of alternatives to coal as an energy source. However, supply disruptions and sustained strong demand for South African low grade coal in Asian markets are threats to low grade coal availability to Eskom. Although South Africa's newly approved nuclear policy would allow the country to diversify its primary energy sources, it would not lead to Uranium playing a dominant role in South Africa's energy mix. Exploitation of the Waterberg Coalfield therefore remains the key to the country's future electricity needs.

3.2 Coal Bed Methane

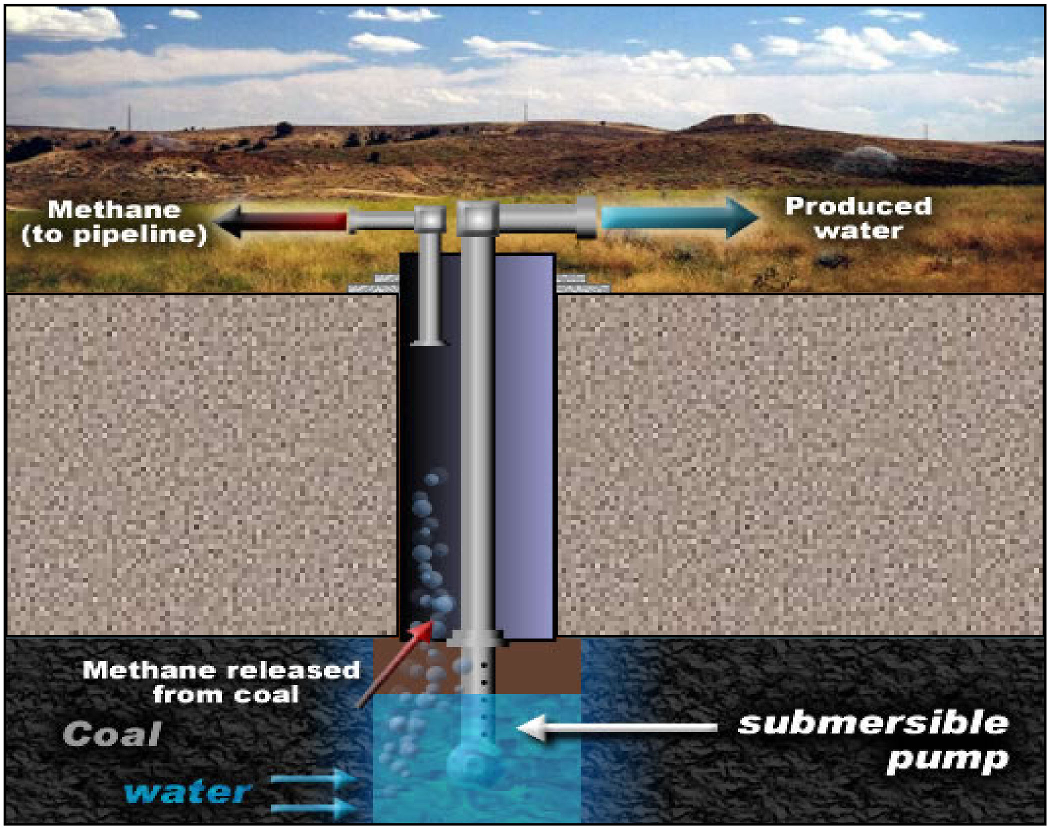
The deep occurrence (more than 400 m) of coal in some parts of the Waterberg Coalfield poses a potentially moderate risk in the conventional extraction of this coal economically. As a result, unconventional extraction methods, such as coal-bed methane (CBM) drainage, need to be employed to release the energy and carbon content of the coal.

The Waterberg coalfield is the only known place in SA where CBM is found. Through the Lephalale CBM project, Anglo Coal is currently exploring the potential for the gas in the area. The project is located in the eastern portion of the Waterberg coalfield, 35 km north of Lephalale (previously known as Ellisras), an area estimated to contain up to one trillion cubic feet (tcf) of recoverable methane gas.

Coal-bed methane is methane gas found in coal seams. The gas forms as a by-product of coalification and/or biogenic processes and its molecules are held in an adsorbed state in internal coal surfaces by hydrostatic pressure provided by the coal seam. The gas is released by reducing hydrostatic pressure, which in turn is achieved by dewatering of the coal seam (Figure 3). The permeability and methane saturation of the coal seam determines the rate of gas flow through the well.

The potential for CBM in the deeper eastern portion of the Waterberg Coalfield was identified by Anglo Coal in the early 1990s following examples in the US where such examples of natural gas could be commercially exploited, depending on various physical factors and the presence of markets and infrastructure. Commissioning of the 5-spot pilot plant occurred in mid-2004 with successful production of CBM from the underlying Grootegeluk formation. Setting up a five-spot pilot entails the drilling of five wells to depths of 500 m and 800 m. The initial trial production period was extended to gather further information for the pre-feasibility study.

FIGURE 3: SCHEMATIC CBM WELL GEOHYDROLOGY (AFTER REF. 4).



The development of the Lephalale CBM project has been moving at a slow pace due to a number of reasons, including its distant location from possible markets. Coal-bed methane can be used to fuel power stations or it can be converted into liquefied natural gas (LNG). It can also be piped to a gas-to-liquid (GTL) refinery for conversion into fuel. It would be possible, for example, to use the methane to generate electricity, using strategically placed combined-cycle gas turbines, such as the ones currently being built by Eskom in Atlantis and Mossel Bay. However, it is not presently viable to pipe the gas to the Western Cape.

The relative newness of the technology to South Africa and lack of gas infrastructure also contribute to the slow pace of project development. CBM could also be transformed to syngas, which in turn could be used for the production of a range of products, including synfuels, methanol, ammonia, and hydrogen. The choice of the product depends strongly on the quantity of gas present and the logistics of getting the products to the market. The state involvement is therefore necessary to develop the infrastructure needed to transport and convert the CBM into usable material.

Gas production at the 5-spot will continue into the foreseeable future to confirm long term characteristics of production. At this stage, Anglo Coal's efforts are focused on developing a second 5-spot to improve the gas resource estimations and lift the level of confidence required to move the project forward.

4. OTHER POSSIBLE MARKETS

4.1 Exports

Although only one-third of coal produced in South Africa is exported, primarily to the European Union (EU) and East Asia, South Africa was the world's fifth largest net coal exporter in 2007. The vast majority of South African coal exports are shipped through the world's largest coal export facility, the Richards Bay Coal Terminal (RBCT).

Increased production from the Waterberg Coalfield is bound to augur well for the Phase V expansion of the Richards Bay Coal Terminal (RBCT) from 72 Mt/year to 91 Mt/a, which was one of the key activities for the coal industry in 2006 and 2007. Increased export tonnage will more than justify the 19 Mt expansion of the RBCT, particularly bearing in mind that the terminal has in the past hardly operated at its maximum capacity of 72 Mt. Already Exxaro plans to export 26 million tonnes of coal from its Grootegeluk coal mine as it increases production there to 120 million tonnes in a decade.

4.2 Coal-to-Liquid Process Technologies

The Waterberg coal has also been earmarked as potential producer of aromatics; primarily benzene, toluene and xylene (BTX). Currently, SA lacks conventional sources of aromatic feedstocks and has been forced to import aromatic derivatives such as plastics, particularly styrene, urethanes and polyamides. Most of the aromatics in the oil industry are utilised in boosting octane, leaving the plastics industry skewed for lack of raw material. As a result, SA is seriously looking at the possibility of producing aromatic feedstocks from coal by direct liquefaction.

Direct liquefaction is an advanced technology that could be done through another coal-to-liquid (CTL) process technology, the Bergius process, as opposed to the

Fischer-Tropsch process used by Sasol. The latter is an indirect process involving half-burning coal with water, with less than 20 percent of carbon in the coal ending up as product. Paraffinic and olefinic compounds dominate in Fischer – Tropsch products and aromatics are almost entirely absent. This is partly the reason why SA, at present, does not produce much aromatics. The Bergius process, on the other hand, is characterised by the addition of hydrogen to coal. In this case, approximately 80 percent of carbon in the coal ends up in the product.

There are several possible reasons as to why the Bergius process has not been implemented. It needs a special coal, one with excellent liquefaction properties, although the coal in the upper series of the Grootegeluk Formation is reported to be the most liquefiable in the world. The process is also less proven than the Fischer—Tropsch process, and the special products it makes presently have limited market in SA. Furthermore, projects will seem very risky since the industry is characterised by years of drought followed by short periods of bliss, resulting in uncertainties regarding profitability.

If implemented, direct liquefaction process could add value to the high phosphorus coal seam of the Grootegeluk Formation. It could also equip the industry with another exportable technology, in much the same way as Sasol has been successful with the Fischer-Tropsch process. Most importantly, though, the process will provide the basis for the products (plastics and petrol) that the country so much needs. Adequate coal reserves are available in the Waterberg coalfield to support a large scale project for a considerable period.

Meanwhile, following the government's decision to scrap a proposed windfall tax on the synthetic fuels industry, Sasol plans to build a mega coal liquefaction plant that would produce 80 000 barrels of oil per day. Both the Free State and the Waterberg are being considered for the project known as Mafutha, which would result in Sasol's synthetic fuels output increasing by more than 50 percent. The proposed plant would have substantial economic spin-offs for the economy, including an expected improvement in the balance of payments worth R40 billion, depending on the prevailing oil price, and the creation of between 5 000 and 10 000 jobs.

4.3 Briquetting

The Council for Scientific and Industrial Research (CSIR) is looking at opportunities of briquetting Waterberg coal fines, a process whereby fine coal powder is combined into lumps of regular size for improved industrial and domestic usage. Briquetting usually employs a binding agent and is used in many industries for many different materials. Fine coal is generated during mining and crushing. It has a high moisture content and as a result it is difficult to beneficiate, handle and transport.

Coal briquetting is not new and has been used in SA before. One of its well known products is charcoal. However, the net price of coal of approximately R200/t after transport costs has led to the need to reduce production costs. This can be achieved through binderless briquetting. As the name suggests, binderless briquetting does not require a binder and is only suitable for high-vitrinite content coals, which produce water resistant products. The process also requires moisture content of less than 10 percent before briquetting. The Waterberg coal meets these criteria and thus is the most probable raw material for binderless briquetting. Products can be used as metallurgical coal, low-smoke household fuel (after devolatilization) and other high-value products.

5. RAIL EXPANSIONS

The Waterberg coalfield has been left largely untouched partly because there is limited rail capacity for higher-priced exports. In anticipation of increased production from the Waterberg due to increased activity in the region, Transnet Freight Rail (TFR) has devised a Rail Master Plan to determine future infrastructural requirements and address operational performance. With over 30 Mt of Waterberg coal envisaged to be available per annum for railage over 450 km, it is clear that access to rail logistics is one of the keys to strategic development of the Waterberg coalfield.

The current coal line export route comprises a dedicated heavy haul line of 580 km from Blackhill in Mpumalanga to Richard's Bay. It has a capacity of 72 Mt of coal per annum and 14 Mt of general freight per annum. Approximately 1.3 billion tons of coal has been exported along this route since 1976. TFR is considering several route options to transport coal from Waterberg to Richard's Bay, Maputo and Saldanha

(Figure 4 and Table 2). In order to give more substance to the rail route proposals, TFR is currently processing a proposal for a pre-feasibility study, which is aimed at ascertaining constraints and requirements of the project.

FIGURE 4: POSSIBLE ROUTE OPTIONS FOR TRANSPORTING COAL FROM LEPHALALE, WATERBERG (AFTER REF. 4).

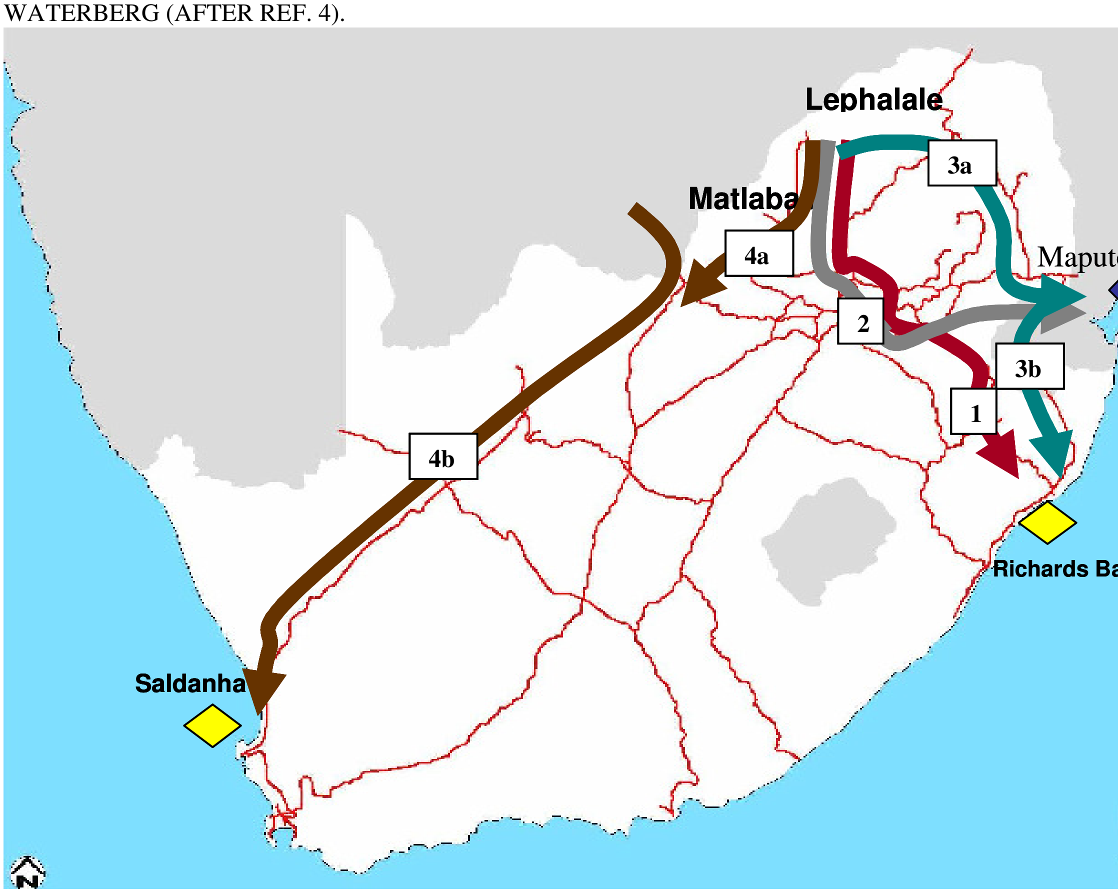


TABLE 2: DISTANCES OF VARIOUS ROUTE OPTIONS.

Scenario	Route	Distance (km)
1	Lephalale – Pyramid - Richards Bay	1050
2	Lephalale – Pyramid - Maputo	950
Alternative Routes (new links)		
Scenario	**Route**	**Distance (km)**
3	a) Lephalale – Groenbult-Richards Bay	***1185***
	b) Lephalale – Groenbult- Maputo	***900***
4	a) Lephalale-Rustenburg-Saldanha routing	1800
	b) Botswana-Mafikeng-Saldanha routing	1430

6. SOME CHALLENGES

6.1 Water Augmentation

Water is one of the scarcest resources in the Waterberg area, with the current surface water supply coming from Mokolo Dam. The dam was constructed in the late 1970's to provide 28,6 Million cubic meters (Mcm) per annum, of which 7,3 Mcm is utilised by Matimba power station, 9,9 Mcm by Grootegeluk coal mine, 1,0 Mcm by Lephalale and adjacent urban water users and 10,4 Mcm by irrigation downstream of an area of 2000 hectares.

Developments in the Waterberg area present a need to meet requirements for water utilisation. As a result, the Department of Water Affairs & Forestry (DWAF) has commissioned investigations that are collectively known as the Mokolo River Catchment studies.

The Mokolo River Catchment covers an area of 8 387 km, stretching from Waterberg Mountain through the upper reaches of the Sand River and includes the Mokolo Dam and a number of small tributaries that join the main Mokolo River up to its conflux with the Limpopo River. The outcome of these investigations will enable DWAF to determine the availability, amount and utilisation of water in the system, in order to issue licenses for lawful water use.

There are several possible solutions for future water requirements in the Waterberg area. These include raising the Mokolo dam, as the dam was designed to be raised, by 8m or 15m, resulting in extra yields of 10 and 21 million cubic metres per annum (m^3/a), respectively. Another option is to transfer provisionally reserved 45 million m^3/a of water from the Crocodile River to Mokolo catchment. Other possibilities include groundwater use, water management and conservation as well as re-use of return flows. Therefore, the DWAF has the responsibility, in accordance with the Water Service Act (1997), of ensuring sufficient water supply to the country and the people of Lephalale in particular, for both economic growth and subsequent poverty eradication.

6.2 Socio-Economic Impacts

An increase in coal demand from both Matimba and the under-construction Medupi power stations necessitates an expansion in the labour forces for both Eskom and Exxaro Resources, thus creating additional job opportunities during both the construction and the operational phase. The current power station constructional phase, which is estimated to last for approximately 42 months, has already created a number of temporary employment opportunities and will involve about 5 000 workers. The majority of workers, approximately 60 percent, are expected to be sourced from Lephalale and the surrounding areas.

Due to high unemployment rate, a huge influx of job seekers will be expected in the area, leading to possibly fierce competition between newcomers and local residents. Increased population might result in increased crime, alcoholism, drug abuse and sexually transmitted diseases. Alcoholism and drug abuse, in particular, have been significant social problems in the area and increased activity might exacerbate the situation. Under such circumstances, both the government and the private sector have a role to play to ensure acceptable social stability and poverty alleviation in the area.

7. CONCLUSION

There can be no denying that the Waterberg Coalfield is a very important energy source for the long-term future of South Africa, which is why much of the attention has been focused on developing and further exploiting this coalfield for the economic benefit of the country. However, care must be taken not to abandon other coalfields, particularly the Witbank-Highveld Coalfields, while their exploitation is still economically viable. It would therefore be beneficial to conduct an in-depth review of coal resources and reserves in these coalfields, in order to ascertain the true extent of their exploitation. The presence of more untapped coal resources in these coalfields is a distinct possibility, which can result in relatively small but lucrative production projects that can further boost the country's production. The Waterberg Coalfield therefore needs to be seen as a future coal resource of the country and a significant attention should be directed at fully exploiting the current proven reserves and converting resources into reserves.

Certain barriers to development need to be lowered before the full economic potential of the Waterberg can be realised. These include lack of expertise in certain projects, such as the CBM project, lack of infrastructure and the effective monopoly on certain businesses. In order to overcome these challenges, the development of the Waterberg needs to be seen as a long-term project to be undertaken in phases. Economic development is sure to follow from the current expansion of coal-mining and power generation, both of which will stimulate the growth of secondary industries that support mining and downstream activities. This increased economic activity will also stimulate other sectors of the local economy, including tourism. It is therefore clear that the exploitation of this vast coal resource will have major, positive economic implications for Limpopo province and the South African coal industry.

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