Thermal coal products in South Africa

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Synopsis

This article captures the intrinsic differences of thermal coal products, their utilization and their substitution characteristics. South Africa produces approximately 245 million tonnes of coal annually. Eskom consumes 46% (approximately 112 million tonnes), 26% (approximately 65 million tonnes) is exported, and SASOL Synthetic Fuels consumes 18% (approximately 44 million tonnes) and a further 9% (approximately 22 million tonnes) is consumed by domestic users in various different industries. Marketing theory contributes significantly to understanding the importance of technical product and quality appreciation and comprehension, encompassing elements of price, distribution, and promotion. Coal product specification is determined by the inherent geology of a resource and the number of complex actions to market the product to a specific consuming market. Sampling, analyses, beneficiation application, and an array of parameters contribute to matching thermal coal products to the value-in-use it provides to the different markets and its consuming industries. Coal producers have come under increased scrutiny since South Africa has been experiencing electricity shortages since early 2008. General misunderstandings were declared on public forums and in the media by both legislators and the South African public since a perception developed that South African coal producers are exporting coal that could be utilized by Eskom.

Keywords
Thermal coal, multi-seam mining, specifications, beneficiation, marketable coal products, marketing terms, penalties, Standard Coal Trading Agreement, globalCoal

Introduction

South Africa remains one of the most important coal producing countries in the world—not only because it is the seventh largest global coal exporter, but also because it burns substantial amounts of thermal coal for generating and delivering electricity. The easy and direct access to abundant thermal coal as well as its use as a cheap energy source has meant that four main markets have developed for South African coals over the years since is discovery. These four markets include the global export market, the domestic synfuels market, the domestic energy supply, and the domestic heating and industrial use. Approximately 27% of all saleable coal produced in South Africa is exported to energy providers, cement, and metallurgical plants in mainly Europe, South America, China, and India. Eskom consumes 46% of saleable low-grade coal production for electricity supply to the national and international grid. SASOL Synthetic Fuel consumes 18% of South African production which is produced entirely by SASOL Mining. The remaining 9% of saleable production is consumed by South Africa's domestic market, which is divided in 12 user groups. Of the domestic market production 38% is traded by merchants, indicating that an extensive trading market is operating within South Africa (Steyn, 2010).

Each of the markets, exports, synfuels, Eskom and domestic, have differing requirements in terms of coal quality, thermal characteristics, and sizing, and this means that the supply of products is quite differentiated in terms of petrographic characteristics, and value-in-use. Special mention is made of SASOL Synthetic Fuels, since it consumes more than all the other domestic industries collectively. The market for thermal coal is relatively mature, with very little in the way of product development. However, as coal resources are depleted on a global scale and mining conditions become more difficult, consumers adapt their quality requirements where necessary and if possible substitute limited quantities of coal for products from different markets (Steyn, 2010).

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The varying geological and depositional environments of coal seams means that mining gives rise to a diversity of marketable coal products. The geological setting of the reserves largely determines the characteristics of the coal product to be marketed, but application of appropriate mining methods together with increasing levels of beneficiation can be applied to ensure that the product delivered meets and satisfies consumer specifications. Application of such measures during production implies increased costs which the coal marketing arm of the company has to monitor against current market prices. The principles of optimal resource use means that efficiency and profitability must be combined to extract value from deposits made up of multiple coal seams. The international cost curve, based on FOB cash costs, indicates the relative competitiveness of each coal producing entity, and is in turn indicative of competitiveness in each of South Africa's four main markets. A producer's position on the cost curve in global terms can provide essential information about the potential for market penetration and expansion of production, but developing a domestic cost curve is also essential if producers are to achieve and maintain competitiveness in terms of their supply to Eskom and other domestic industries (Steyn, 2010).

Whereas the product is thermal coal, there is a requirement that marketing professionals develop an understanding of the technical conditions and requirements for each of the four distinct markets supplied in South Africa. This enables the supplier to deliver a coal with the correct specifications, and to secure, consolidate, and maintain a long-term off-take relationship between the producer and consumer through customer satisfaction. Some coals can be placed on the market without the need for any form of beneficiation. This does, however, mean that the thickness of the coal seam should be wide enough to ensure that coal extraction is possible without contamination by hanging wall or footwall lithology, or dilution by lower grade portions of the seam. Screening, crushing, hand-picking, and beneficiation maybe essential for thinner seams of high quality coal that are subject to contamination and dilution during extraction. Although such intervention adds to the cost of production such processing ensures higher prices are achieved through delivery of consistently high quality thermal coal(s). Beneficiation plants add substantial value when operated in tandem with mining operations that deliver a continuous and consistent run-of-mine feed without unnecessary stoppages. The final product of the mining and beneficiation activities must be technically excellent (meet or exceed customer specifications) and competitive in terms of cost of production. Yet again, these parameters are different for each of the four markets supplied in South Africa (Steyn, 2010).

Coal product specification

The function of the coal marketer can only be initiated once a full product specification, the basis of discussion between a producer and consumer, has been provided by a prospective customer. The product then offered is presented to buyers as a typical specification, that includes proximate analyses, ultimate analyses, polymorphs of sulphur, hardgrove index indications, ash fusion temperatures, analyses on calorific value, and an ash composition. Products can be marketed on a dry, air dried or as received basis, and the marketer should ensure that the consumer or buyer understand the basis of will be used in the process of contracting. Companies historically develop their branded, typical specification sheet based on the parameters set out above, and in terms of domestic and Eskom marketed coal, these specification sheets are widely used.

The export market has evolved to the extent that the Standard Coal Trading Agreement (SCoTA) specification parameters are used for basic trading. This is a standard specification known as RB1 and includes analyses only on calorific value, total moisture, volatile matter, ash, sulphur, hardgrove grindability index, ash fusion temperature, and calcium oxide in ash. The specification for thermal coal is defined in terms of its typical quality. The typical quality is classified in the composite of proximate analyses, ultimate analyses, calorific value, forms of sulphur and milling. Consumers and buyers often request additional analyses on milling, ash composition, and ash fusion temperatures. Table I shows an example of a specification sheet for marketing purposes taken from an operating mine in South Africa. The specifications are for typical export product, but can also be applied to domestic and Eskom marketing purposes. All the elements of the analyses are reported, and form the basis for all initial marketing communications. The customer is supplied with a final analysis of the typical quality of a shipment by an independent laboratory that analyses the product at the point of dispatch. The analysis should indicate all the elements on the specification sheet have been tested scientifically, and are true and correct.

The marketer is responsible for matching the range of mined and beneficiated products to specific metallurgical customer requirements and applications. Generally, the first indication of a product's compatibility in a specific application is usually determined by ash, calorific value, volatile matter and sulphur (refer to Table I). Once these parameters have been found to lie within acceptable limits, elements such as phosphorus, ash fushion temperatures and abrasiveness index are considered. A metallurgical assessment is then made on sizing to confirm the product's acceptability to a specific application. Notwithstanding the first assessments, the employment of the full specification as set out in Table I remains the deciding factor for a coal product's use in any application.

Eskom

Eskom is the largest producer of electricity in Africa, and among the top seven utilities in the world in terms of generation capacity and among the top nine in terms of sales. The company generates approximately 95% of electricity used in South Africa. Currently, Eskom has 24 power stations in commission, consisting of 13 coal-fired stations (3 of which had been in cold reserve storage, 1 nuclear station, 2 gas turbine stations, 6 hydroelectric stations and 2 pumped storage schemes. The total nominal capacity of Eskom power stations is 42 011 MW. The net maximum capacity of Eskom power stations is 36 208 MW (Eskom Annual Report: 2008).

Eskom operates on MWe (megawatt electrical), and base load generation percentages, as set out in Table II. Base load (or base load demand) is the minimum amount of power that

Table I

Typical specification sheet of coal quality

Typical quality (all analyses on a air dried basis unless otherwise indicated)					
Proximate analyses			**Calorific value**		
Inherent moisture	%	3	Gross specific energy	MJ/kg	27
Total moisture	%	8		kcal/kg	6500
Ash	%	15	NAR specific energy	MJ/kg	25
Volatile matter	%	28		kcal/kg	6000
Fixed carbon	%	54	**Ash composition**		
Ultimate analyses			SiO_2	%	49.24
Carbon	%	70.8	Al_2O_3	%	23.84
Hydrogen	%	4.49	Fe_2O_3	%	11.07
Nitrogen	%	1.61	TiO_2	%	1.56
Oxygen	%	23.1	P_2O_5	%	0.30
Sulphur	%	1.4	CaO	%	4.81
Forms of sulphur			MgO	%	1.73
Pyratic	%	0.878	Na_2O	%	0.36
Sulphatic	%	0.051	K_2O	%	1.07
Organic	%	0.271	SO_3	%	4.47
Total	%	1.200	MnO	%	0.03
Milling			BaO	%	0.18
HGI		56	Sr	%	0.18
Abrasion index		243	V_2O_5	%	0.05
Ash fusion temperatures			Cr_2O_3	%	0.06
Reducing			ZrO_2	%	0.11
Deformation temp.	°C	+1220	Total	%	99.05
Spherical temp.	°C	+1250			
Hemisphere temp.	°C	+1280			
Flow temp.	°C	+1320			
Oxidizing					
Deformation temp.	°C	+1260			
Spherical temp.	°C	+1310			
Hemisphere temp.	°C	+1340			
Flow temp.	°C	+1380			

Table II

Capacity and generation of Eskom power stations

Power station	MWe capacity	Two-shifting generation	Base load generation
Arnot	2100 MWe		90.72%
Duvha	3600 MWe		90.37%
Hendrina	2000 MWe		84.51%
Kendal	4116		90.69%
Kriel	3000		90.53%
Lethabo	3708		87.79%
Majuba	4110	35.28%	
Matimba	3990		92.09%
Matla	3600		92.16%
Tutuka	3654	60.56%	
Camden	1600	Reopening	
Grootvlei	1200	Reopening	
Komati	1000	Reopening	

(Source: Eskom, 2009)

a utility must make available to its customers, or the amount of power required to meet minimum demand based on reasonable expectations of customer requirements. Base load values typically vary from hour to hour in most commercial and industrial areas. A base load plant is an energy plant devoted to the production of base load supply. Base load plants are the production facilities used to meet some or all of a given region's continuous energy demand, and produce energy at a constant rate, usually at a low cost relative to other production facilities available to the system. A two-shifting generation plant is a power plant that adjusts its power output as demand for electricity fluctuates throughout the day (Doyle, 2005).

Eskom product

Eskom utilizes coal for electricity generation, based on high ash thermal coal consumption. The energy value required by Eskom is inferior to domestic (A-grade) and export quality production, but is customized for use in these power plants. Moreover, the mineable product originates from different geological coal seams which dictate that mining will yield more than one product, marketable to different consumers. Efficiency and profitability for mining companies are optimized by extracting value from multiple seams. This in turn, contributes to the cost of Eskom produced coal and the market price to remain at fairly low levels (<R200 per tonne free-on-mine).

Eskom has a dedicated procurement department, which include a technical and commercial team. This team ensures that the contracted product quality can be consumed by an assigned power station. Although the range of quality specifications is fairly similar, Eskom makes a distinction between the qualities consumable by different power plants. Usually, the difference is a 2 per cent range in ash and volatile matter and 2 MJ/kg in calorific value.

Saleable product from a producer is usually paired with an Eskom power plant that has the ability to use the specific product and is at close proximity or a fair distance from the power plant. When contracting with a producer is done, Eskom has a standard operating procedure (SOP) whereby it is contractually stated that product has to be on stockpiled for a minimum of 3 days, and that these stockpiles will be pre-certified by the Eskom technical team. Operationally, the producer has to follow the SOP in detail to ensure following of the contractual obligations Eskom is instructing in terms of product quality.

Table III specifies the Eskom required product, and the rejection column indicates when the product will be unacceptable to Eskom. The coal specification for the 13 operational power plants is essentially the same with permutations on ash content, calorific value, volatile matter and abrasiveness index, although the rejection rates differ in some instances. Sizing is specified to be 0 x 40 mm product.

Should the producer supply coal in the rejection range in respect of qualities other than volatile matter, which is rejected immediately, Eskom imposes penalties equivalent to 30–50% of the cost of free-on-truck coal for the period is imposed, given that these are single production days. If rejected material is produced longer than three days, Eskom rejects the total free-on-truck cost of coal for each day. As a result, Eskom has the right to instruct the producer in writing to stop delivery until such time as Eskom is satisfied that the coal qualities are acceptable. Furthermore, Eskom has the right to cancel an agreement should any coal quality be in rejection range for any cumulative seven days of a specific calendar month.

According to the data in Table III, it is evident that only the moisture sulphur contents for domestic and export quality coal are comparable; all other parameters are entirely different. The potential for substituting domestic and export coal to the Eskom market is very limited without destroying value (Steyn, 2010).

SASOL Synthetic Fuels

SASOL Synthetic Fuels consumes an estimated 42.5 million tons of coal per annum (DME Statistics 2009), the second largest consumer of domestic coal. Coal production forms the basis of gasification feedstock and is utilized at SASOL's complexes in Secunda and Sasolburg. The coal is utilized in raw, crushed form and is produced mainly by SASOL Mining operations. The typical quality of coal produced and consumed by SASOL Synthetic Fuels is shown in Table IV.

Considering the product specification, it is very similar to Eskom product (Table III), although calorific value, ash and volatile matter is superior, and ash is lower than the required Eskom product. SASOL Synthetic Fuel product is, however, not a suitable substitute for Eskom product. This is mainly due to the fact that the value of this product as feedstock for fuel and chemical production is unsurpassed when compared

Table III

Eskom coal specification and rejection ranges

Parameter	Units	ESKOM	Rejection
Calorific value (basis)	MJ /kg (NAR)	21	20
Total moisture	Maximum % (AR)	10.0	12.0
Ash	Maximum % (AR)	25–33	>35
Volatile matter	Minimum % (AR)	20	20
Sulphur	Maximum % (AR)	1.0	2.0
Abrasiveness index	Maximum	500	550

(Source: ESKOM Technical Team, 2009)

Table IV

SASOL synthetic fuels coal specification

Parameter	Units	SASOL syn fuel
Calorific value (basis)	MJ /kg (NAR)	20-22.64
Total moisture	Maximum % (AR)	10.0
Ash	Maximum % (AR)	20-29.7
Volatile matter	Minimum % (AR)	21-26.9
Sulphur	Maximum % (AR)	>1.0

(Source: SASOL Technical Team, 2009)

with the value it could yield as Eskom product, both in price and quality specification. SASOL Mining Operations produce and commit the coal only for consumption by SASOL Synthetic Fuels, and production plans are intended to supply into the production of gas and chemicals on a long-term basis.

Domestic market

The South African domestic market consumes an estimated 22.7 million tons per annum that includes approximately 4 million tons of anthracite and semi-soft coking coal. Most notable is the 8.5 million tons categorized as merchants and domestic coal that is distributed to other industries, via retailing merchants and traders that buy from producers and on sell to consumers. Effectively this translates that thermal coal consumption in the domestic market is approximately only 10 million tones. Table V below provides the total tons of coal consumed on an annual basis in South Africa.

Thermal coal in the mentioned industries is utilized mainly for energy generation, and as carbon reductants. The main distinction as depicted in Table VI, in domestic graded coal and export coal is sizing. The domestic coal market uses different sized products, as application boilers, kilns and furnaces require different sizes of any particular grade coal.

Table V

South African domestic coal consumption in 2008

Industry	Consumption per annum
Gold and uranium mines	8 736
Agriculture	27 324
Brick and tile	68 628
Mining	536 040
Cement and lime	815 532
Arcelor Mittal steel	1 083 372
Electricity	1 299 060
Metallurgical	1 531 560
Chemical industries	1 754 628
Iron and steel	3 156 144
Industries	3 845 256
Merchants and domestic	8 599 320
Total	22 725 600

(Source: DME, December 2008)

Table VI

Domestic coal specifications

Parameter	Units	A grade	B grade	C grade	D grade
Calorific value	MJ /kg ad	>27.5	>26.5	>25.5	>24.5
Total moisture	Maximum % (AR)	12.0	12.0	8.0	8.0
Ash	Maximum % (AR)	15.0	16.0	18.0	21.0
Volatile matter	Minimum % (AR)	24.0	23.0	23.0	23.0
Sulphur	Maximum % (AR)	1.0	1.0	1.0	1.5

(Source: South African Classification, 2009)

These products are produced from active screening. Three coal products, according to sizing are consumed domestically:

- ➤ Duff—0 x 6 mm
- ➤ Peas—6 x 25 mm and
- ➤ Small nuts— 25 x 40 mm.

The domestic market also has the ability to consume A–D grade coal. Table VI shows that the distinction between grades of coal is dependent on the ash content and calorific value. The lower the ash content and higher the calorific value, the higher the grade of coal, as indicated below. Note that domestic coal calorific value is expressed as MJ /kg, whereas export product calorific value is expressed in kcal/kg.

The product mix listed in Table VII provides information on the coal consumers (industry) within the South African coal market coupled with the coal sizing and grade of material that can be consumed within that industry. This indicates that mining and screening of the coal will yield different products, distributable to different consuming markets, e.g. A-grade unsized product is screened, and from yielded production, the cement and lime industry can be supplied with duff, the mining industry with peas, and the metallurgical industry with small nuts.

The product specification for domestic thermal use, indicates that substitution with Eskom products is very low for A–C grade, although D-grade could be have potential to substitute Eskom products. From the specification, it is assumed that substitution between A and B Grade coal can be made with export product, although value is lost if sized product is used for export substitution, as there exists a cost implication as a result of screening.

Export product

Export coal in South Africa is classified as RB 1 and RB 2 (RB = Richards Bay) coal. The classification of RB product is as a result of the globalCoal platform that was commercialized in 2000, which is essentially an over-the–counter (OTC) platform. In general this is also referred to an A-grade product.

Table VII

Domestic product mix for grade and size

Industry	Coal grade	Coal sizing
Gold and uranium mines	A; B	Small nuts
Agriculture	B; C; D	Peas
Brick and tile	C; D	Duff
Mining	A; B	Peas, Small nuts
Cement and lime	A; B; C	Duff
Arcelor mittal steel	A; B;	Small nuts
Electricity	B; C; D	Small nuts, peas
Metallurgical	A; B	Small nuts, peas
Chemical industries	A; B	Small nuts
Iron and steel	A; B	Small nuts
Industries	A; B; C; D	Small nuts, peas
Merchants and domestic	A; B; C; D	All

(Source: South African Classification, 2009)

RBCT comprises 17 stockpile grades, and export material mainly constitute this product specification, with smaller tonnage and stockpile space assigned to semi-soft coking coal, anthracite and 10% thermal or pulverized coal injection material. For the purposes of discussion, only RB 1 and RB 2 will be discussed, being 15% ash thermal coal with a 6 000 kcal/kg calorific value, and is represented in Table VIII as the exact RB 1 (and RB 2) coal specification.

Export coal product in South Africa is fairly generic in terms of the maximum and minimum parameter distinction for RB 1 and RB 2 coal, with only higher volatile matter in RB 2. Export product, is mainly classified as such, if the product has a sizing similar to 0 x 50 mm, a calorific value of 6 000 kcal/kg, an ash content lower than 15%, and volatile matter of at least 22% on an as received basis. Sized material with a sizing of 6 x 40 mm and hard grove index of a minimum of 60 is exported ex-Durban Dry Bulk Terminal. The reason for this is that Durban Port is a soft loading facility which is essential for loading sized material.

Recently, South African producers have seen a permutation, of what has always been known as standard export specification, with the emergence of India as a major buyer. Higher ash content with associated lower calorific value material is bought by Indian consumers since Indian power plants are designed to utilize lower quality input coal. Higher sulphur content is also tolerated by Indian consumers, and this introduces an opportunity for producers to supply, as many lower sulphur reserves are becoming depleted

This contributes to producers being faced with the decision to beneficiate lower quality material at a higher yield, but at a discounted price. The market has certainly evolved in this regard, and a number of companies have made the decision already, although greater move towards lower quality, higher yield is expected within the next 5 years. This is mainly as a result of India's (and China's) insatiable demand for coal, and its geographic advantage to South African markets.

It is evident that South African produced export coal maintains the highest quality of coal consumed internationally, and is compatible for use by international buyers. Although export quality could be reduced to supply typical lower quality Indian buyers, the reduced quality coal is not a substitute for Eskom coal.

However, export coal quality coal can be substituted for A–B domestic used coals, but only on technical specification. Costs will be incurred to screen export production to be acceptable in different sized fractions.

Conclusion

In considering thermal coal as the product consumed by Eskom, the export and the domestic market, it is clear that each market has distinctive product specifications, sizing and marketing terms associated with it. This concludes that the product sold to ESKOM is intrinsically different from the product that South African producers export, and to the A-C grade products used in domestic industries. Production of each product originating from different coal seams is often interdependent as geology and mining makes provision for different products from one mining process. Differentiation in product occurs only once beneficiation takes place. Geology and washability of the coal are the first step in developing a marketing plan and strategy. The producer cost curve, based on FOB cash costs, is the curve ranking each producing country in terms of costs competitive and contribute to South African producers driving cost down in an effort to stay globally competitive. FOR and delivered costs also contribute to the ultimate indication of a producer's competitiveness, and has to be considered coupled with technical specifications.

It has to be noted that production is derived from multi-seam mining in South Africa, and middling product is often the delivered Eskom product. It would be highly inefficient and unprofitable to mine only particular coal seams and not extracting value from multiple seams for Eskom and export products. Technically, the product is the most important element in the marketing mix, since the technical analyses and composition is marketed in bulk, and the product is bought from a technical specification. It is evident that the marketing manager should have superior technical

Table VIII

Typical export specification for South African thermal coal

Parameter	Units	RB1 maximum	RB1 minimum
Calorific value	kcal/kg (NAR)	6,000	5,850
Total moisture	% (AR)	12.0	<8%
Ash	% (AR)	15.0	<10%
Volatile matter	% (AR)	>25.0	22.0 *
Sulphur	% (AR)	1.0	<0.8
Hardgrove index		70	45
Ash fusion temperature	oC	>1,250	1,250
Calcium oxide in ash	% (DB)	12	
Sizing	0 x 50 mm		

* For RB2 Specification, volatile matter has to be a minimum of 25%
(Source: SCOTA, 2009)

Table IX

Thermal coal product specifications

Parameter	Units	Eskom	Domestic	Export
Calorific value	(NAR)	21–24 Mj/kg	24.5–27.5 Mj/kg	5850–6000kcal/kg (27.5 Mj/kg)
Total moisture	% (AR)	8–12	8–12	8–12
Ash	% (AR)	25–34	15–21	15
Volatile matter	% (AR)	20–30	23–30	22-20
Sulphur	% (AR)	0–2	0–1.5	0–1.0
Hardgrove index			45–70	45–70
Ash fusion temp	°C			1.250
Phosphorus	%		0.001–0.01	0.001–0.01
Calcium oxide in ash	% (DB)			12
Sizing	mm	0x40 mm	0x6 mm 6x25 mm 25x40 mm	0x50 mm

(preferably mining and metallurgical) knowledge of the product, but also of the process in which the coal will be used as energy fuel. The technical specification sheet is the fundamental starting block of marketing coal, and a full understanding of proximate and ultimate analyses, ash fusion temperatures, calorific value and ash composition is essential for successful marketing.

Thermal coal is used by the various markets in two applications—power generation and cement manufacturing. Coal is used either in a pulverized or sized form as feeder fuel in burners and stokers. Stokers and burners have different specifications and usually the product can be adapted in terms of size for optimal utilization. In cement manufacturing coal is fed according to the kiln feed composition and fine material is used. Technically, the marketing manager need a full understanding of the product required by individual customers, based on their stoker, burner or kiln specifications and requirements. Table IX represents a summary and comparison of the different coal products with their typical specification. As indicated, it is clear that the parameters not only differ per product, but each product has individual parameter applications and reporting. The information is summarized for Eskom, domestic and export market products. Products can be marketed on a dry, air dried or as received basis, and the marketer should ensure that the consumer or buyer understands the basis of contracting.

Production for export and domestic A-grade utilization is of superior quality with substantial higher energy and calorific values, and products are custom produced for these markets. The exception is B and C-grade production destined for the domestic market, although these products will not be the desired quality for Eskom utilization. Superior technical knowledge and analyses are demanded of the technical and marketing teams servicing the customer, albeit based on the specific utilization of the product.

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