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Coal Exports and the Diversification of Botswana's Economy

Roman Grynberg



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Abstract

The paper considers the opportunities and risks associated with the development of Botswana's steam coal export sector. Given the very high coal prices on world markets achieved over the last decade together with the growing demand in India and China for steam coal, Botswana with its massive estimated potential coal deposits of 212 Bt, probably the largest in Africa, is in a position to develop a new export sector which will further diversify the diamond dependent economy. However, the potential to develop this export sector has a narrow window of opportunity because of the declining relative price of renewable energy and the changing global setting with regard to fossil fuels. Unless the necessary infrastructure is put in place soon, including a railway to the coast, the development of national water grid and industrial policy to utilize the middlings and discard from coal exports, then the sustainable development of an industry that could be part of the country's diversification program could well be put in jeopardy.

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Executive Summary

1. Botswana has considerable coal deposits, one of the largest untapped potential reserves in the world at over 212 billion tonnes, 77% of which remains in the ‘hypothetical’ and ‘speculative’ categories. It has been estimated that as much as two thirds of Africa’s coal resource is found in Botswana.
2. Four commercially significant coal deposits at Morupule, Mmamabula, Sese and Mmamantswe on the eastern edge of the Central Kalahari Karoo Basin have been explored to a point where it is possible to conclude that an export industry of at least 36Mt/a growing to as much as 90Mt/a is possible. By way of comparison South African coal exports in 2010 were 70 Mt. However, with some notable exceptions, Botswana’s coal deposits are of low quality.
3. Until 2000 coal prices have been very stable but over the last decade prices have been rising rapidly and greater price volatility is also evident.
4. Estimates of global supplies of coal vary but estimates from the coal industry indicate sufficient reserves until the next century. Independent estimates suggest that ‘peak coal’, that is maximum global production, will occur between 2030- 2050 and that some 90% of global coal reserves will be exhausted by 2070.
5. Estimates of the growth of global demand for coal suggest that growth rates of 1.5% per annum can be expected to 2035. These estimates are however based on the assumption that there will be no significant reductions in Green House Gas (GHG) emissions.
6. There have been significant changes in renewable energy policy in two of Botswana’s potential markets – India and China. China has recognized the limits of its own coal reserves and has aggressively moved towards the development of renewable energy sources. China is now the world’s largest producer of solar panels and the largest generator of wind power. India has moved more tentatively on its renewable energy policy but has also begun the development of tax and emissions trading that will limit GHG emissions.
7. The results of COP17 in Durban suggest that both India and China now accept as inevitable a greater degree of legal limits to GHG emissions by 2020. At that point both countries will have fully implemented their domestic policy to cap GHG emissions.
8. There have been significant changes in the economics of solar electricity generation. Real solar energy prices have been falling at the rate of 7% per annum in real terms in the US and grid parity for solar prices is expected after 2020.
9. Given the mushrooming of thermal electricity facilities in Asia, which have a commercial life of at least 30 years, Botswana can reasonably expect significant coal demand to support an export industry for the next 20-30 years.
10. While Botswana’s coal exports will be based on long term contracts, it will almost certainly be a swing producer with low ROM prices and high FOB prices given its location. There is considerable price risk for Botswana as less geographically remote countries enter the Asian market to supply coal. The potential for significant structural over-supply of coal in the 2020’s and 2030’s with the ensuing price declines and volatility should not be discounted.

- 11) Two important pieces of infrastructure are essential in order to develop a viable, significant and sustainable coal export industry.
 - a. The first is a new railway to the coast. Two competing projects are currently being considered are those to Ponta Techobanine in Mozambique and the Trans-Kalahari to Walvis Bay. Both entail environmental risks. The route to Mozambique is closer (1100km) and it is to the Indian Ocean therefore facing Botswana's potential markets in India and China. The Mozambique route faces sovereign risk given the transit via Zimbabwe.
 - b. The second is the development of national water grid using water from Zambezi. A 90mt/a coal export industry, based on current estimates will require 40Mm³/a of bore water. Over a period of 20-30 years this level of abstraction is of the most doubtful sustainability. Ground water is currently gratis in Botswana and large abstraction activities such as mining needs to be priced to reflect opportunity costs.
12. The development of a coal export industry will produce a considerable volume of middlings and discards. An export of 90Mt/annum is likely to produce a similar volume of middlings and discards. Their use in electricity generation for the local and regional market could use a portion of this low quality coal. Exploring the development of a coal to liquids facility (CTL) is essential to make optimal use of this resource. However, CTL using Sasol technology would require approximately 6-7l of water per litre of fuel produced. Modern air cooled systems require much lower volumes of water ie 1.5 litres of water per litre of fuel produced. There exists a number of possible strategic partners for such a facility which include China, South Africa and the US.
13. A coal export industry, even with exports of 90Mt/a cannot alone constitute a substitute for diamond revenues and mining which are currently expected to go into decline around 2026. However, coal exports, while no a panacea to Botswana's diversification concerns can make a substantial contribution to government revenue, exports and employment.
14. Given the gestation period of railroad construction (3-5 years for construction and 12-15 years for cost recovery) government needs to move expeditiously on a railroad decision given the uncertainties of coal prices and demand following 2030.

1. Introduction

This paper reviews the existing literature on the coal industry and draws on recent studies in the area. It evaluates the opportunities as well as risks and possible mitigation strategies that Botswana needs to implement as it attempts to diversify its economy away from a high rate of dependence on diamond exports. The government of Botswana is expected to issue a Coal Road Map in 2012 as it sees coal as one of the more propitious areas for economic diversification. This paper begins with a consideration of the global supply and demand of coal based on what is currently known from geological estimates. Given the global supply/demand situation and the availability of very large greenfield deposits in the country there exists good medium term prospects for the development of a coal industry in Botswana. The paper considers the opportunities created by the development of the thermal coal sector and then considers in detail the risks and constraints facing the sector which include the availability of water and adequately priced transport for the very large volumes of coal to the Indian or Atlantic Oceans. The potential coal export sector also confronts serious long term challenges given the changes in electricity generating technology and the rapid decrease in costs of renewable sources of electricity. Lastly, there has emerged a changing global policy environment as it pertains to coal, renewable energy and GHG emissions and this will be considered as this is shaping the long term future of coal.

2. The Global Coal Production and Use

a. Global Supply

What constitutes global coal reserves and how this has changed is considered below. As will become evident the question of the emerging global supply and demand situation will determine the viability of a coal export sector emerging in a remote location such as Botswana. The various definitions of resources and reserves which reflect the level of knowledge regarding a particular deposit and the assumptions that are made with regard to price and other factors are vital in understanding the various gradation of the definition of reserves and resources¹.

i. What are Global Reserves?

In 2009 world coal reserves amounted to some 860 billion tonnes, of which 405 billion (47%) is classified as bituminous coal (including anthracite), 260 billion (30%) as sub-bituminous and 195 billion (23%) lignite. Global proven reserves are 1.3% greater than 3 years previously. This indicates that despite rising usage, discovery and determination of proven reserves still continues to outpace demand. However, the long term trend, as we shall see below is to downgrade these reserves in almost all countries.

Of the world's larger producers it is only India and Australia which have managed to reclassify resources into reserves over the past two decades. Indian hard coal reserves have been upgraded over time from 12.6 Bt in 1987 to 90 Bt in 2005. Australian hard coal reserves have been upgraded from 29 Bt in 1987

¹ Estimates of the volume of coal is divided into *reserves*, which are defined as being proved and recoverable, and *resources*, which include additional discovered and undiscovered/inferred/assumed/ and speculative quantities. The *World Energy Council (WEC)* classifies reserves and resources according to the following.

Proved amount in place is the resource remaining in known deposits that have been carefully measured and assessed as exploitable under present and expected local economic conditions with existing available technology.

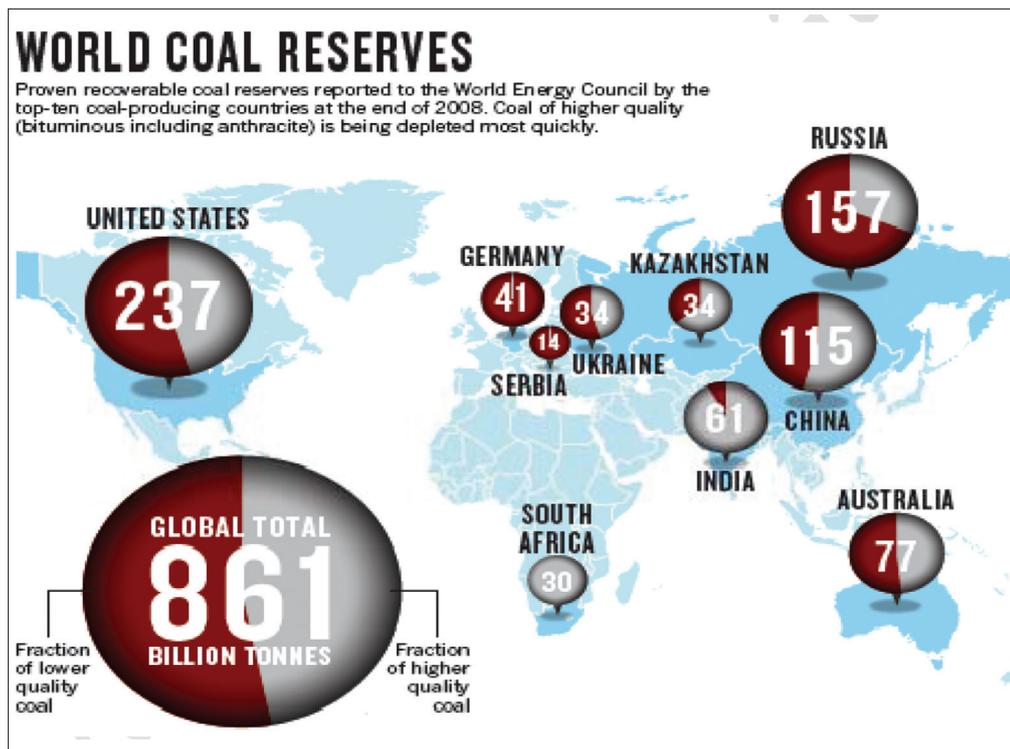
Proved recoverable reserves are the tonnage within the proved amount in place that can be recovered in the future under present and expected local economic conditions with existing available technology.

Estimated additional amount in place is the indicated and inferred tonnage additional to the proved amount in place that is of foreseeable interest. It includes estimates of amounts that could exist in unexplored extensions of known deposits or undiscovered deposits in known coal-bearing areas, as well as amounts inferred through knowledge of favourable geological conditions. Speculative amounts are not included.

Estimated additional reserves recoverable is the tonnage within the estimated additional amount in place that geological and engineering information indicates with reasonable certainty might be recovered in the future.

to 38.6 Bt in 2005. All other countries have individually downgraded their hard coal reserves by a combined 35% over the same period. On the global scale, hard coal reserves have been downgraded by 15%. The cumulative coal production over this period is small compared to the overall downgrading and is thus no explanation for it.

The countries with the largest recorded coal reserves are the USA, the Russian Federation and China with nearly 60% of global reserves between them, while Australia and India are also in the top rank countries. In all some 75 countries possess proven reserves of coal, eight more than in the 2007 owing to the availability of estimates for Armenia, Bangladesh, Belarus, Bosnia-Herzegovina, Georgia, Laos, Macedonia (Republic) and Tajikistan.

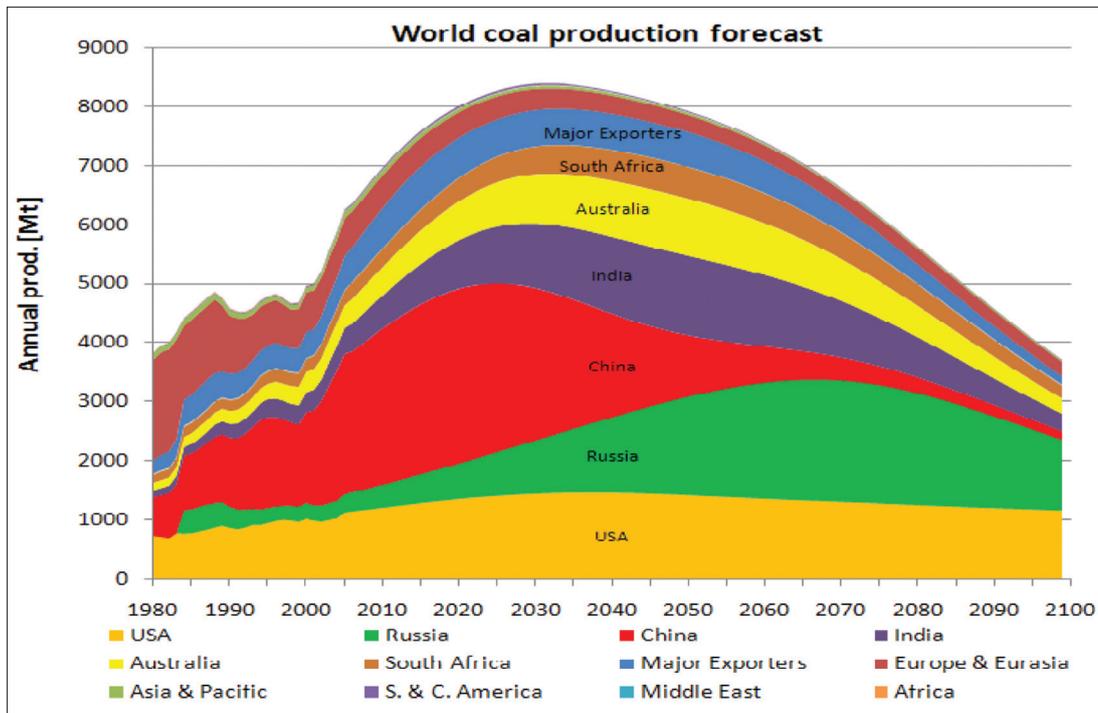


ii. Peak Global Coal Supply

Historically it has been considered almost a truism of global energy policy that coal reserves were of such an order of magnitude that they would last many generations. Indeed the very first significant assessment of the huge British coal deposits done in the middle of the 19th century by independent geologists as well by the British Royal Commission into the subject indicated that they would last into the 4th millennium²:

British coal has lasted 150 years, not 1100 years (suggested by Hull in 1861). British mines produced 27Gt of coal, not Hull's 81 Gt nor the Royal Commission 149 Gt....it is clear that both Hulls numbers and the Royal Commission's were not good estimates... nowhere in the world, then or now are one or two foot seam routinely mines at 4000 ft.

² Rutlege, D Estimating long-term coal production with logit and probit transforms' International Journal of Coal Geology , Vol 85, (2011) pp23-33



Source: Hooika et.al (2008) p.43 **NB** Prior to 1985 the Russian coal production is included in Europe and Eurasia. Major exporters include Canada, Colombia, Indonesia, Kazakhstan and Poland. The most optimistic scenarios are used for the USA and China.

What constitutes proven reserves is ultimately dependent upon the assumptions used by geologists and engineers however what was observed in the UK in terms of overly optimistic assessments of global reserves has also occurred with global estimates of reserves. The standard quantification of reserves has undergone substantial and continual downward revision over the years³.

What has become evident is that those countries which industrialized first in the 19th and early 20th century, that is UK, Germany and Japan, and based their industrialization on coal, have long ago reached peak coal and coal production is insignificant despite the existence of a potential resource.

There is increasing evidence that peak global production of coal will occur in the current century⁴. The most recent estimates suggest that peak coal will occur between 2030- 2050 and that some 90% of global coal reserves will be exhausted by 2070⁵. It should be noted that the coal industry does not share these estimates and believes significant coal supplies will continue until the 22nd century⁶.

³ Mikael Hööka, Werner Zittelb, Jörg Schindlerb, Kjell Aleklett a 'A supply-driven forecast for the future global coal production', 2008, <http://www.tsl.uu.se/uhdsg/Publications/Coalarticle.pdf>

From the latest edition of *BP Statistical Review of World Energy* one can see that the USA has an R/P ratio for coal of 234, i.e. it will be able to keep on producing coal at the current production volumes for 234 years. If one looks at previous years one will notice something odd. In year 2000 the US had 255 years of coal remaining, and in 1988 there were 300 years of coal reserves. In 1904 the reserves would last a thousand years and 10 000 years in 1868. As each year goes by and production increases the coal reserves will diminish faster and faster. In the global picture the trend is very clear. In 2000 the reserve-to-production ratio of the world was 227 years and this had decreased to 147 years in 2006. The decrease is over 35% in just seven years. So the "hundred years of coal remaining" is not there in reality, as available amounts of coal will diminish much faster

see also Mikael Hööka, Werner Zittelb, Jörg Schindlerb, Kjell Aleklett a (2010) Global coal production outlooks based on a logistic model, *Fuel*, Volume 89, Issue 11, Pages 3546-3558

⁴ Mohr S.H. and Evans G.M. (2009) 'Forecasting coal production until 2100', *Fuel*, Volume 88, Issue 11, Nov, pp. 2059-67 These authors suggest that peak production will occur on a tonnage basis between 2010 and 2047.

⁵ Rutledge op.cit page 23

⁶ 'At current production levels, proven coal reserves are estimated to last 118 years, with recoverable reserves in around 70 countries. In contrast, proven oil and gas reserves are equivalent to around 46 and 59 years at current production levels respectively and over 62% of oil and 64% of gas reserves are concentrated in the Middle East and Russia.' <http://www.worldcoal.org/resources/coal-statistics/> Downloaded 16th November 2011.

However, much of the geological analysis of peak coal has not examined the impact that the declining production capacity on coal prices and as we shall see below the rising demand for traded coal from India and China will have a dramatic impact on the market and prices could rise sharply as supply is unable to meet demand⁷. This is likely to occur long before substantial reserve declines occur.

The most recent independent estimates suggest that peak coal will occur between 2030-2050 and that some 90% of global coal reserves will be exhausted by 2070.

b. Global Coal Demand

i. By End Use

The largest global consumer of coal is the power generation sector, which in 2008 used almost 60% of global coal production. Metallurgy (iron and steel making) used 16%, mainly superior quality bituminous coal type, called coking coal. The residential & agricultural sector used 14% of the coal, for domestic heating and small-scale heat generation. Cement and other industries use the remaining 12%.

Electricity

The dominant technology for the combustion of coal is the pulverized coal combustion method which is used in over 90% of the world's coal-fired power plants. It is based on combustion of a finely milled coal powder instead of coal lumps. The estimates of the amount of coal required to generate a kWh of electricity vary from plant to plant and the interests of those undertaking the estimate. For example, the Morupule B feasibility study estimates that when at full production the plant will require approximately 3 million tonnes of coal per annum to fuel a 600 MW facility⁸. This is not untypical of such thermal facilities.

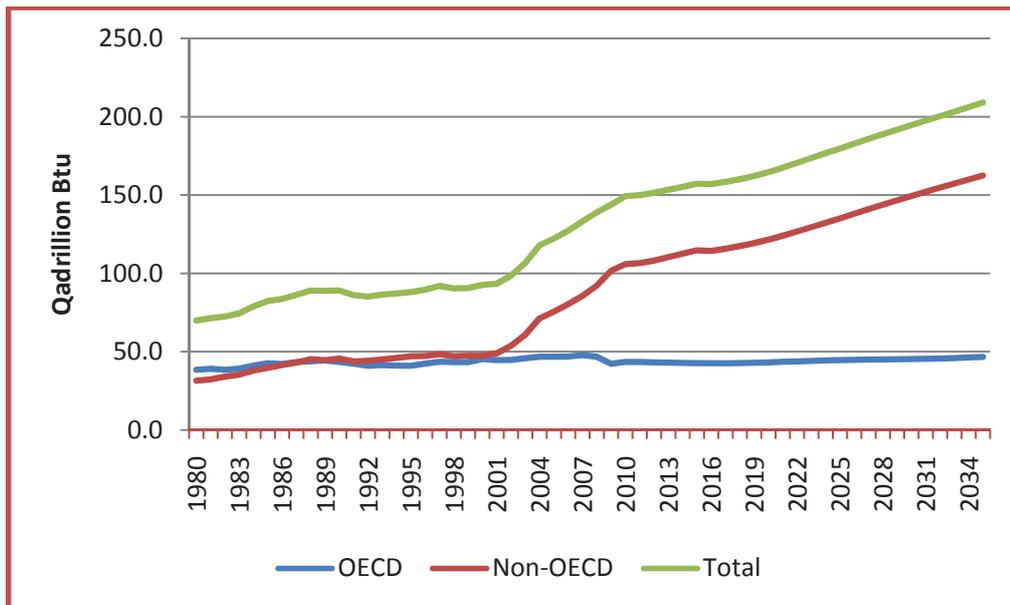
According to US Energy Administration global demand for coal is set to increase at a rate of 1.5% per annum from 2010 to 2035⁹. The demand for coal in OECD countries is expected to be flat while Asian growth will dominate global demand. It is important to note these demand projections are made on the assumption that there are no prospective greenhouse gas emission reductions. These estimates foresee a 50% increase in global coal consumption largely for electricity generation. This assumption, irrespective of whether an international agreement on Green House Gas emissions is agreed, is unrealistic as regional and national initiatives to lower GHG emissions and decrease import dependence are already starting to shape global demand for fossil fuels.

⁷ Richard Heinberg and David Fridley.(2010) 'The end of cheap coal' Nature 18 Nov, vol 468, pp.367-369

⁸ World Bank (2009) 'Project Appraisal Document on the Morupule B Generation and Transmission Project, Report No: 49183-BW

⁹ www.eia.gov/forecasts/ieo/coal.fcm, downloaded 4th April 2012

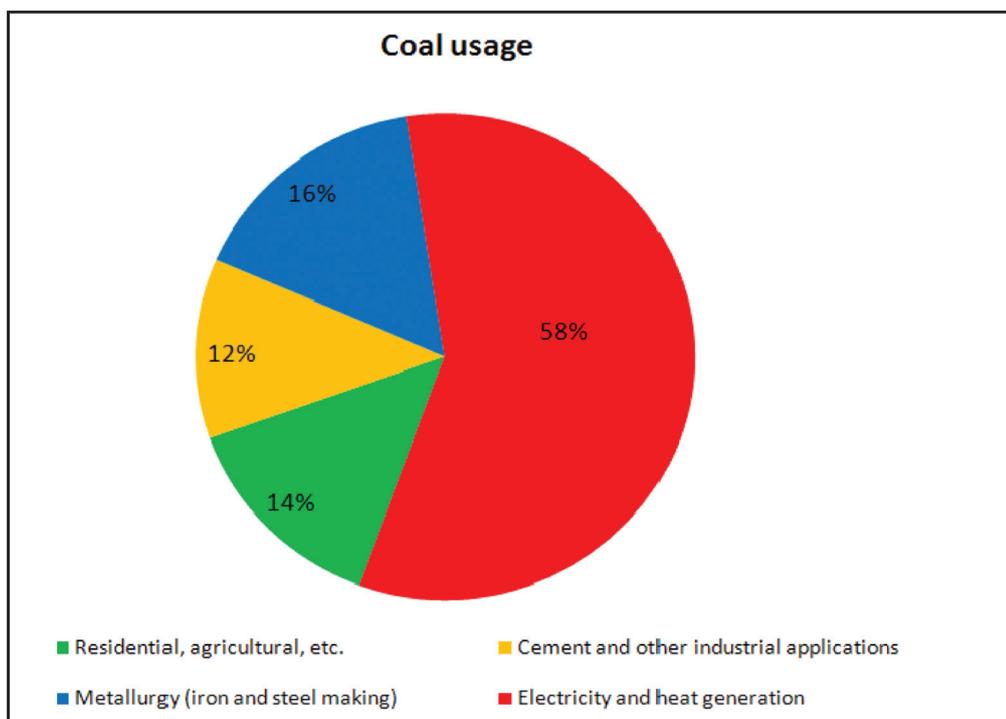
Global Coal Demand Projections (2010-2035)



Source: International Energy Outlook, US Energy Administration, 2011, <http://www.eia.gov/forecasts/ieo/coal.cfm> downloaded 4th April 2012.

Iron and Steel

High quality coking coal is used in the iron and steel industry as a reducing agent, i.e. to reduce iron oxides to iron. The most common process for this is the blast furnace, which is a coal consuming method. Around 60% of the global steel production is based on ore and the rest on scrap metal. Ore-based production requires around 0.7 coal/kg steel products¹⁰. Scrap metal-based production consumes much less coal and only marginally affects the total coal consumption of the iron and steel industry.



Source: 'Fostering the use of clean coal technologies: the CARNOT programme' European Commission Luxembourg: Office for Official Publications of the European Communities, 2001

¹⁰ Hooka, (2008) op cit, p. 11

Cement

The basic ingredients of cement are calcium carbonate, silica, iron oxide and alumina. These are then partially melted, thus altering their chemical and physical properties, in a high-temperature kiln and the resulting material is called clinker. The clinker is then pulverized and mixed with gypsum to make cement. Coal is normally used as an energy source for the kilns. Large amounts of heat and energy are needed to form cement and coal is an ideal fuel for the purpose. The typical consumption is 450 grams of coal for 900 grams of cement produced¹¹.

Coal demand remains inextricably associated with the rapid economic growth of newly industrializing countries. The need for electricity as well as steel and cement for construction are three of the main inputs needed in the development of emerging economies. The high rates of growth of these countries, especially China and India will continue to drive coal demand in the coming decades.

By Country

Most steam and coking coal is not traded internationally and despite the exponential growth of international trade in the last two decades, the international market for coal remains a residual market where domestic coal prices are often at considerable variance to international market prices. Most coal demand is met from domestic sources leaving countries with room to maneuver on electricity price policy, a vital element of national commercial policy. In 2010, world hard coal production increased by 6.8%, compared to 1.8% in 2009. It continued to be driven by growth in production from the non-OECD countries with 8.4% The biggest six producers of hard coal are responsible for some 85% of total world production and while production occurs in many countries few are as dependent on hard coal as the biggest producers. Significantly with the exception of Brazil production and consumption is increasingly concentrated in the BRICs countries with South Africa being the most dependent upon coal as a source of electricity of any country in the world with 93% of estimated 2009 supply.

Top Ten Hard Coal Producers (2010e)

PR China	3162Mt	Russia	248Mt
USA	932Mt	Indonesia	173Mt
India	538Mt	Kazakhstan	105Mt
Australia	353Mt	Poland	77Mt
South Africa	255Mt	Colombia	74Mt

Source: World Coal Organization <http://www.worldcoal.org/resources/coal-statistics/>

Steam coal exports have been expanding rapidly in the last decade. Between 1990 and 2000 total traded coal rose from 496Mt to 585Mt, an increase of 17% over the decade. In 1990 traded coal made up approximately 11% of global production and traded coal could be considered a residual market. However by 2010 world exports of coal had increased to 938 Mt an expansion of over 60% in a decade. By far the largest exporter of coal is Australia followed by Indonesia and Russia. However, the international trade in coal now stands at some 17% of 2010 coal production with exports rising rapidly to meet demand in India and China. This means increasingly it will become difficult without significant state control for price differences between the traded and domestic coal

¹¹ World Coal Institute (WCI): Material available at <http://www.worldcoal.org/>

price to be sustained. While Germany and Turkey remain significant coal importers the coal market is now dominated by the dynamic Pacific market which constitutes approximately 60% of world coal trade.

In the coming years coal demand is set to rise rapidly with the growth of Asian economies. According to the World Energy Council¹²:

‘The use of coal is expected to rise by over 60% by 2030, with developing countries responsible for 97% of this increase. China and India will contribute 85% of the increase in demand for coal over this period. with coal’s share in global electricity generation set to increase from 41% to 44% by 2030...’

Top Coal Exporters (2010e)

	Total of which	Steam	Coking
Australia	298Mt	143Mt	155Mt
Indonesia	162Mt	160Mt	2Mt
Russia	109Mt	95Mt	14Mt
USA	74Mt	23Mt	51Mt
South Africa	70Mt	68Mt	2Mt
Colombia	68Mt	67Mt	1Mt
Canada	31Mt	4Mt	27Mt

Source: World Coal Organization <http://www.worldcoal.org/resources/coal-statistics/>

Top Coal Importers (2010e)

	Total of which	Steam	Coking
Japan	187Mt	129Mt	58Mt
PR China	177Mt	129Mt	48Mt
South Korea	119Mt	91Mt	28Mt
India	90Mt	60Mt	30Mt
Chinese Tapei	63Mt	58Mt	5Mt
Germany	46Mt	38Mt	8Mt
Turkey	27Mt	20Mt	7Mt

Sources: BP, IEA, World Steel Association, SSY, WEC, (e = estimated) (Mt = Million tonnes) <http://www.worldcoal.org/resources/coal-statistics/>

The section below considers the market of two of the largest, and from Botswana’s perspective important, coal importing markets in some detail and the role these will play in the coming years in the development of Botswana’s coal resources. It will become evident that the relative price stability of coal that was a dominant feature of the world coal market much of the last century is now a thing of the past with China having moved from the position of being a net exporter to a net importer has changed the nature and risks in the global coal market.

¹² World Energy Council ‘Survey of Energy Resources- 2010’, London 2010, page 3

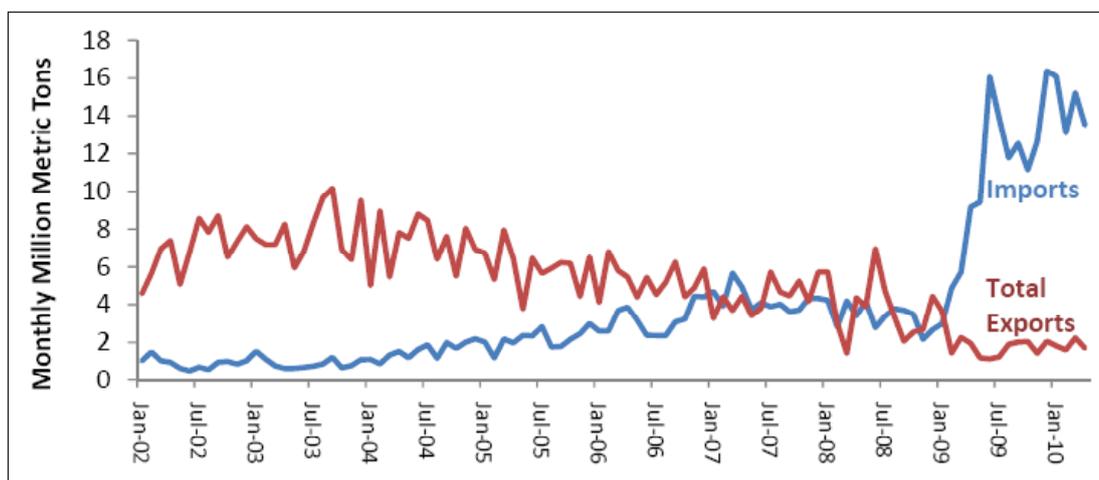
The Chinese Coal market

The Chinese coal market is profoundly different from that of the other emerging Asian player, namely India. Understanding how this enormous market functions is key to understanding what role Botswana will be able to play in global trade and the risks associated with export dependence on that market. At the beginning of the last decade China was a major net exporter of coal and this has only begun to shift since 2009. In large part this move is not caused by absolute shortages of coal in China but rather by the arbitrage possibilities created by the distances between the point of supply in China which are largely in the north and west and the points of demand which are in the south and east of the country. The high cost of transporting coal such long distances first by train and then by sea creates potential for arbitrage trade with neighboring suppliers in Indonesia and Australia¹³:

The middle kingdom's appetite for imported coal seems insatiable, and the "China Factor" appears to have ushered in a new paradigm for the global coal market. But China doesn't "need" the coal. The world's largest coal producer cranked out 2.96 Bt of production in 2009, backed up by 114.5 Bt of reserves.

While China's production was almost 3 billion tonnes, its imports were in 2009 a mere 129 million tonnes which rose yet again to 177 Mt in 2010. This means that imports constituted a mere 5.6% of total supply and yet this had massive impact on Asian markets given that imports had risen from 2008 from a mere 46 million tonnes. The chart below depicts the shift in China's coal trade position. However, what is clear is that given the size of its reserves it would be able to terminate imports at any point and thus the reserve overhang creates the potential for market instability given that its imports are currently 19% of the world market. What is also important to note is that South Africa which would have a similar sea freight cost to South China to that of Botswana exports is only a very minor supplier with exports constituting only 0.6% of total Chinese imports in 2009.

China Imports and Exports of Coal



Source: Morse, 2010 page7

China's coal import market is a very large share of total global imports but small from a domestic perspective and dependent almost entirely on transport costs and efficiency which creates the potential for significant price instability in the global market. However, despite significant reserves the rapidly

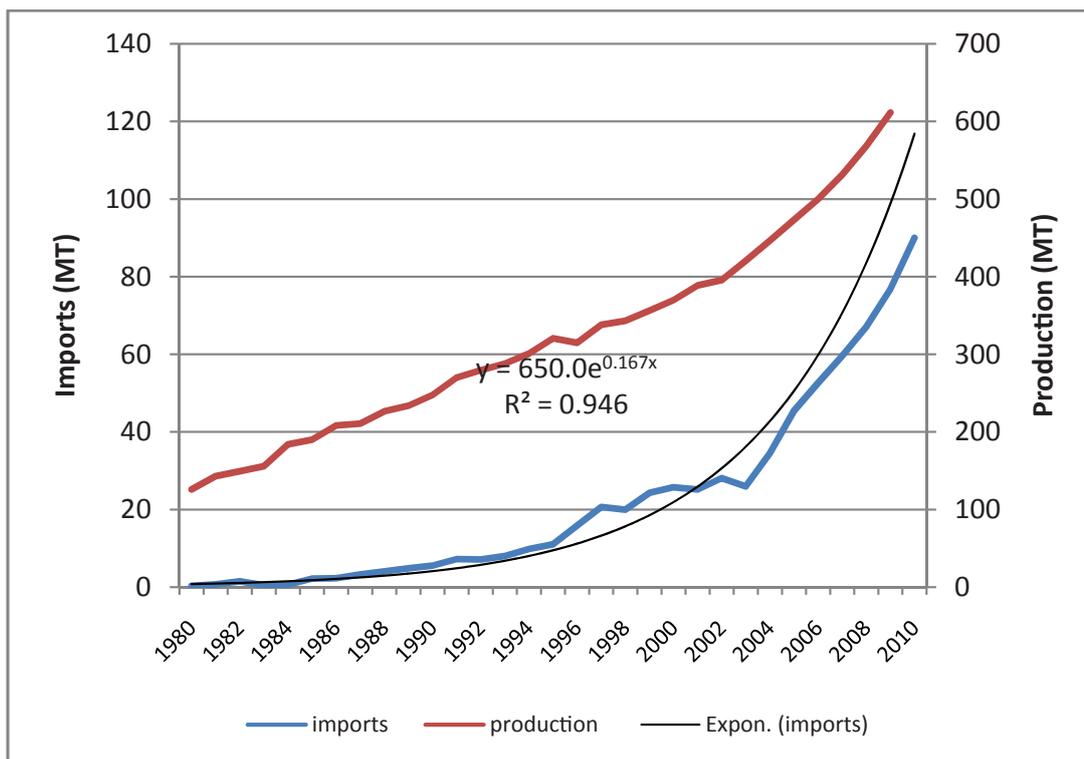
¹³ Morse R.K and Gang H. 'The World's Greatest Coal arbitrage: China's Coal Import Behavior and Implications for the Global Coal Market' Program on Energy and Sustainable Development, Stanford University, Working Paper #94, August 2010

growing demand for coal in China will likely mean that what is currently merely an arbitrage trade in coal, will over the years evolve into a structural deficit of locally produced coal¹⁴. This will in turn create demand for coal which is based on the fundamentals of the market rather than short term opportunities. Unless coal prices rise very rapidly in the coming years China is unlikely to become a major market for Botswana’s coal. India is a far more proximate, structurally ‘short’ and an expanding market.

The Indian Market

The Indian coal market is unambiguously ‘short’, that is, the demand for coal is substantially larger than available domestic supply and India is increasingly unable to meet the needs of either the steel industry for coking coal or electricity generation for steam coal. Based on 2010 data Indian coal imports had risen to an estimated 14% of the total Indian coal market. The growth of imports is depicted below. Indian demand for electricity and coking coal is driving the exponential growth in imports. Furthermore, it is reported that stockpiles of coal in 2011 at electricity facilities are decreasing¹⁵ and Indian companies are increasingly looking to purchasing coal assets in other countries, in particular in Africa. It is expected that India will become a major investor in Botswana’s coal fields given the rate of growth of coal demand¹⁶.

Indian Coal Production and Imports 1980-2010



Source: US Energy Information Administration

¹⁴ Chinese academics Tao and Li forecast in 2007 that China’s production will peak and begin to decline long before the simple 62-years estimate, perhaps as early as 2025. Tao and Li used the Chinese government’s latest official reserves figure of 187 billion tonnes to arrive at their peaking date between 2025 and 2032. Tao, Z. & Li, M. 2007” Modelling energy systems for developing countries”: *Energy Policy* 35, 3473-3482

¹⁵ The Economic Times (Oct 17, 2011). ‘As many as 29 power stations, of the 86 coal-based power projects in India, are currently operating with less than 4 days coal stock and 44 with less than 7 days stock. <http://agneyablog.wordpress.com/2011/10/25/coal-and-power/> downloaded 15th Nov 2011.

¹⁶ Jindahl Steel acquired CIC Energy in September 2012

Given the rate of growth of Indian coal imports it is expected that India will become the largest coal importer replacing China¹⁷. In a recent analysis Indian energy economists have projected coal demand to double from 2006 to 2015¹⁸ with imports scheduled to grow at a pace to meet demand. The coal resource in Botswana remains one of the few ‘Greenfields’ deposits in the world and there is every potential that Botswana will become a major supplier to India in the coming decade assuming the issue of rail transport can be resolved. The most propitious new coal deposits in Botswana are owned by relatively small exploration companies which will, in all likelihood, sell these deposits to Indian companies that will tie production to Indian coal demand.

The constraints to global supply of coal along with the rapid growth of demand for electricity in India and China have created a global coal price structure that will make it viable to export coal from Botswana, most profitably to India, if a new railway system to the ocean can be developed. The duration of the current high prices is uncertain and will be considered below.

3. Background to the Coal Industry in Botswana

a. Botswana’s Coal Resources

The figure below outlines a range of estimates of potential coal deposits in Botswana. As discussed in the sections above the definition of what constitutes reserves varies and in the case of Botswana the estimated resources require a great deal of further exploration. The figure most commonly used for available supply is 212 billion tonnes but as we have above such extremely high estimates of reserves which, if proven would make Botswana one of the world’s largest producers of coal. However even if, as expected, the figure of 212 billion tonnes does not ultimately become proven reserves from what is already known Botswana has the capacity to become a not insignificant coal exporter once a railway is built to the coast. Based on these figures Botswana contains what is likely to be 2/3 of Africa’s coal resources.

For at least 40 years there has been consideration given to the development of Botswana’s known coal deposits¹⁹ which have been known since well before independence. However, intensive exploration requires the economic impetus that can only come with the building of an appropriate railroad to the coast so that further exploration can be justified. Until 1990 no feasible development was possible as a railway would have had to cross the territories of then white minority regimes and countries in a state of civil war ie Namibia and Mozambique. It was not until the end of apartheid in 1994 and resolution of the many regional disputes that were associated with the conflict in South Africa that the geopolitics allowed the development of a potential railway.

Unless the state is to initiate such a project a private railway developer would in effect have to develop a railway route on a speculative basis i.e. prior to the existence of the cargo for export. Geologically Botswana is likely to have more than adequate coal reserves and current world prices are high enough in the new emerging markets to justify a new line to the coast. Once a railway line comes into existence many of the

¹⁷ ‘Coal to keep burning on strong Asian demand’ by Julien Girault (AFP) ‘By 2020, when it comes to coal imports, India will be a new China as the largest importer of coal in the world. Coal will be very competitive for a long time,’” Richard Jones, Deputy executive director of the International Energy Agency told AFP in an interview.

¹⁸ Kumar, U. & Jain V.K. (2010) ‘Time Series Models (Grey markov, Grey Model with rolling mechanism and singular spectrum analysis) to forecast energy Consumption in India’ *Energy*, Vol 35, pp 1709-1716

¹⁹ See Government of Botswana (1974) Report on Coal Exploration and Development Policy, PD-NCB Consultants, London

known deposits in the table below will almost certainly be further explored and the very large portion of the speculative and hypothetical deposits will be further delineated. This will inevitably mean that like the situation that we saw in the section above what will ultimately be found to be proven coal reserves will very likely be considerably lower than the 212 billion tonne figure which is now commonly used. It should be noted that based on currently available public data 77% of the estimated resource remains in the hypothetical or speculative category i.e. the least information is known²⁰. Equally, from what is already known with some degree of certainty, adequate reserves exist for a significant export industry to develop. These are presented in the table below which presents the official 2012 tonnage estimates for Botswana²¹.

2012 TOTAL TONNES (IN-SITU) AFTER GEOLOGICAL LOSSES, Top 200-300m only						
Coalfield	Deposit	Company	Total Tonnes	Measured	Indicated	Inferred
Dukwe	Dukwe	Asenjo	922Mt		508Mt	414Mt
Foley	Sese	African Energy	2,800Mt	~500Mt	2,200Mt	109Mt
Foley	Sese NW	Daheng	850Mt		850Mt	
Serule	Sechaba	Shumba	968Mt			968Mt
Serule	Lechana	Asenjo	830Mt		103Mt	727Mt
Serule	Tshimoyapula	Asenjo	1,174Mt			1,174Mt
Morupule	Morupule	Debswana	2,900Mt	425Mt		2,483Mt
Morupule	Morupule South	Hodges	2,330Mt			414Mt
Moiyabana	Moiyabana	Hodges	1,500Mt			1,500Mt (target)
Mmamabula	Mmamabula	CIC Energy	2,346Mt	2,313Mt	2Mt	31Mt
Mmamabula	Mmamabula West	Asenjo	5,364Mt		573Mt	4,791Mt
Mmamabula	Mmamabula South	Under tender	617Mt	553Mt	57Mt	7Mt
Mmamabula	Mmamabula Central	Under tender	408Mt			408Mt
Letlhakane	Mmamantswe	Aviva Corp	1,300Mt	895Mt	405Mt	
Dutlwe	Takatokwane	Nimrodel	4,230Mt			4,230Mt

TOTAL: 28,539Mt 4,686Mt

Source: African Energy

Since the 1970's with its escalating oil and energy prices, interest in the coal resources of Botswana has attracted the attention of several companies which included Shell BP and Anglo American. This in turn resulted in a significant part of the country being studied with varying degrees of intensity. Very large resources of high ash, medium calorific value, low-medium quality bituminous coal have been confirmed to exist in Botswana²². The thicker and better-quality coal seams are found near the eastern margin of the Central Kalahari Karoo Basin (e.g. Mmamabula and Morupule areas) and towards the basin interior, the coals are relatively thin with much admixed muddy and silty material²³.

At present, the only operational coal mine in Botswana is at Morupule and has the best quality coal²⁴. The Mmamabula area also contains coal of similar grade to that at Morupule and potentially contains

²⁰ Skepticism regarding the eventual size of such large deposits is justified however there can be little doubt that existing deposits are significant, increasing in proven size and if the development occurs quickly sufficient to justify the necessary infrastructure development. On 16th November Nimrodel Resources, announced the Australian stock exchange that at its Takatokwane Coal Project in Botswana it had inferred resources of 4.23 billion tonnes of coal (2.9 billion washed). This is close to the Dukwi deposit and is larger than previous inferred deposits at Dukwi of 1.57 billion tonnes. <http://www.nimrodel.com.au/media/files/2011%20Nov%2016%20maiden%20JORC.pdf> downloaded 25th November 2011.

²¹ The estimates provided by African Energy are current JORC/SAMREC/NI-43 compliant estimates. These are respective industry and stock exchange reporting standards for mining companies in Australia, South Africa and Canada

²² See Clark, G. C., Lock, N. P., Smith, R. A., 1986. Coal resources of Botswana. In: Anhaeusser, C. R. and Maske, S. (eds.). Mineral Deposits of Southern Africa. Geological Society of South Africa, Johannesburg, 2071 – 2085.

²³ Sebaga T (2008) The Geological Framework and Depositional Environments of the Coal-Bearing Karoo Strata in the Central Kalahari Karoo Basin, Botswana, MSc Thesis, Rhodes University, See also Smith, R. A., 1984. The Lithostratigraphy of the Karoo Supergroup in Botswana. Bulletin 26, Geological Survey, Botswana,

²⁴ See Clarke et. al. (1986) op cit.

more significant deposits. Many of the coalfields in the rest of the country, closer to the Central Kalahari Karoo Basin such as those Dutilwe, Serule, Foley, Dukwi, Pandamatenga, Bobonong (Tuli), and Ncojane appear to have less favorable targets for exploration due to different factors such as intrusions and faulting.

Location of Botswana's Coal Resources



Source: Sebaga (2008) p31

b. Known Commercial Deposits and Potential Exports

The one operating mine in Botswana at Morupule exists principally to supply the adjacent Morupule power station. At least three other possible coal deposits are sufficiently explored to be potentially commercial at current world prices. The only inhibiting commercial constraint to the full development of Botswana's coal fields lies in the development of appropriate transport infrastructure.

i. Morupule

Morupule Colliery Ltd (MCL) is Botswana's only operating coal mine, and has been in production since 1973. The company is owned by Debswana (50% Botswana Government, 50% De Beers). The colliery was originally established to supply coal to Bamangwato Concession Limited (BCL) Copper/Nickel mine and its adjacent coal fired power station established by the Botswana Power Corporation (BPC). Coal was dispatched by rail to both operations located at Selibe-Phikwe, some 150km to the North East.

The coal mine is situated in the eastern part of Botswana, approximately 14 km west of Palapye on the road to Serowe. The Morupule lease area contains coal of a medium to low grade sub-bituminous coal suitable for steam raising. The mine life extends to at least 2032 (period of the current lease).

While the colliery supplies BPC as the primary client, other major clients are BCL and Botash. For Morupule Colliery the planning, preparation and implementation of activities associated with the

expansion of the current operation are being developed under the banner of the “MCL 1 Expansion Project”. MCL 1 Expansion Project will increase the capacity of the colliery to 3.2 million tonnes per annum (mtpa). The increase in production capacity is required to meet coal supply deadlines associated with Botswana Power Corporation’s (BPC’s) new Morupule B Phase 1 600MW thermal power station. There are 5.5 billion tonnes of measured and indicated coal.

ii. Mmamabula

In 2005, Coal Investment Corp. (CIC) of Canada and Meepong Investments (Pty.) Ltd. of Botswana entered into a joint venture to reevaluate the Mmamabula coal project. Mmamabula previously had been explored extensively by a number of organizations, which included AMAX Exploration Inc. of the United States, Anglo American Corp. etc. Mmamabula’s inland location and lack of process water had thwarted the prospect’s development as a coal export project in the early 1980s. In 2005, CIC’s local subsidiary, Meepong Resources (Pty) Ltd., proceeded with a feasibility study of the Mmamabula license. The mineral resource assessment undertaken by the company has shown a measured resource of approximately 2.6 billion tonnes.

The original intent of the project was, given the absence of rail capacity, to establish a market for electricity in South Africa under an IPP agreement with Eskom. This was intended to be one of the largest independent power producers with a planned capacity of 3,600 MW given the proximity to the South African power grid. Given the apparent reluctance shown by Eskom and the Government of RSA to develop IPPs the project was scaled back to 1,200 MW, of which a quarter is intended for sale to BPC. CIC says that it has the capacity to export approximately 16 MT of coal per annum once a new rail network is built. It is a proponent of the trans-Kalahari route which would see coal transported 1,500 to Walvis Bay.

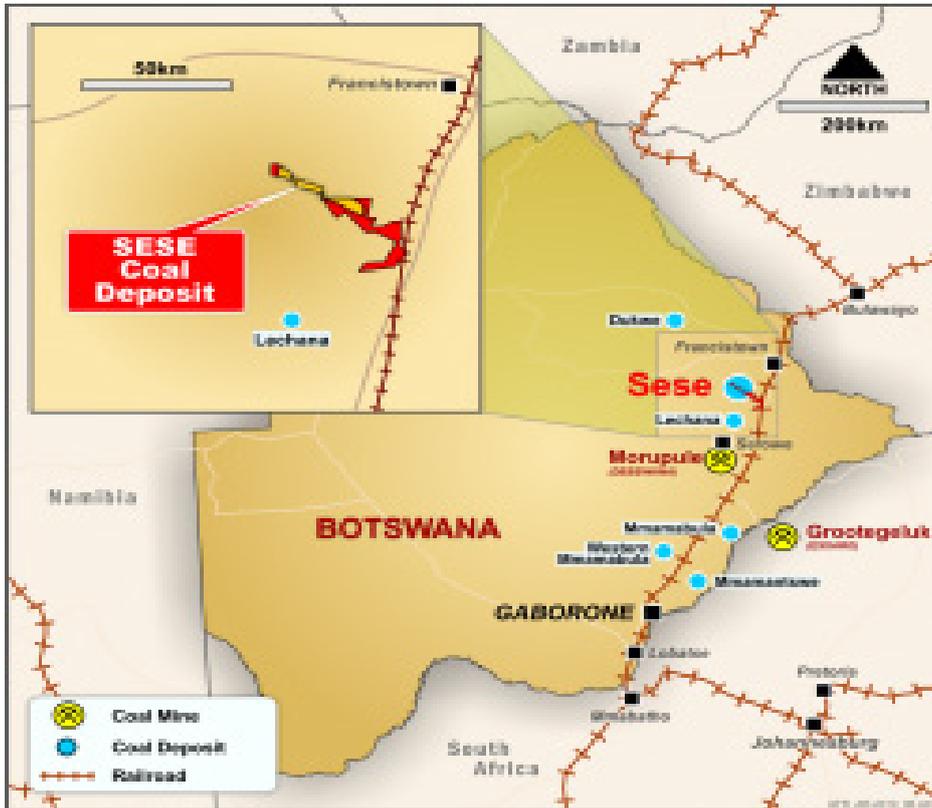
iii. Sese Coal Project

While drilling on the company’s uranium targets, African Energy Resources (AER) made a discovery of a large (2.6 Billion tonnes of Indicated and Inferred resources averaging 4,000 kcal/kg) thermal coal deposit at its Sese project within 20-50 metres of the surface. The deposit is found 50km south of Francistown on the main rail network. It is expected that all work including resource estimation will be completed by 2012 and the Sese Property Licence has been renewed for a further period of 2 years.

The project proposal envisages coal being produced initially for domestic consumption or with a further 2-3 Mtpa going to Zambia, Zimbabwe or India through existing rail networks. However, the company intends to move to large scale coal exports and suggests that total exports could reach 6 Mtpa. The indicative time line presented by the company estimates that it will be producing coal by 2012. The company is undertaking a conceptual study to consider export potential of approximately 20 million tonnes of coal once the either the Ponto Techobanine or Trans-Kalahari routes are completed²⁵. According to the developers operating costs for the mine are low by comparison with South African mines in large measure because of the low strip ratio. At an estimated 20 Mt throughput the facility is expected to deliver ROM prices of USD 8.40/tonne²⁶. This would put the mine in the lower quintile of South African operating coal mines. Washing costs are estimated at a further USD 2.90 per tonne.

²⁵ <http://www.africanenergyresources.com/projects/botswana/sese-coal-project.html> Downloaded 15th November 2011.

²⁶ Presentation by African Energy to Investors , November 2011 ‘Unlocking The Potential of Botswana’s coal Sector’ Gaborone



iv. Other Deposits

Other potential new developments include the Mmamantswe deposit which is being developed by Aviva Corporation. The deposit is located 70 km north of Gaborone with probable reserves in the vicinity of 900 Mt. With a throughput of 10Mtpa this is expected to be a relatively low ROM price of ZAR 75/tonne²⁷.

A new deposit has also been announced to the Stock Exchange by Nimrodel Resources at Takatokwane in the Central Kalahari NW of the Jwaneng Copper mine. The company announced a 4.23 BT Inferred Resource. It has commenced work on a scoping study. This particular deposit is notable both for its size as well as location. It is one of the few major deposit found in the centre of the Central Karoo basin.

From current known resources Botswana has a capacity to export approximately 36 MT of coal per annum from the existing deposits once they are operating and the new rail system to either the Atlantic or Indian Oceans. Based on data available from firms this figure could increase as Morupule, the only established mine considers potential exports. Exports of up to 90Mt/a are foreseen by government.

²⁷ Presentation by Aviva Corporation, November 2011 'Mmamantswe Coal Project' Gaborone.

4. Opportunities Created by Coal Exports

The opportunities created by the future development of the coal industry are not inconsiderable. Most significantly, if the government moves in a timely manner to make decisions pertaining to the infrastructure considerable trade and commercial advantages exist for Botswana. In light of the expected decline in diamonds revenues post-2027 coal will be one of the most important new sectors for Botswana that will cushion but not fully absorb the impact of the decline in diamond revenues. The table below suggest that while estimates vary from 36 Mtpa to a possible 90 Mtpa a more realistic figure of 72Mtpa is used in the analysis.

Coal Production, Exports, Employment, and Revenue Projections

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Production (Mt/a)	0.2	1.1	6.2	13.2	19.1	31.6	43.4	48.7	57.5	62.4	62.4	67.9	72.9	72.9	72.9
Exports (Billions Pula)	0	0	1	3	5	8	12	10	11	13	13	16	17	18	19
Employment (000s)	83	324	1,177	1,911	2,652	3,825	4,743	5,177	5,707	5,945	5,943	6,391	6,759	6,756	6,756
Nominal Government Revenue (P. Millions)	-	59	126	1,201	1,790	2,699	2,933	2,000	1,789	1,898	2,018	2,815	3,173	3,191	3,246
Real Government Revenue (P. Millions)	-	55	112	1,015	1,441	2,079	2,142	1,391	1,185	1,197	1,212	1,610	1,729	1,656	1,605

Source: Freeman and Fichani (2012) ‘Minerals and Energy Export and Revenue Projections’ A report Commissioned by BIDPA for BOCCIM

The table above summarizes the expected economic benefits of coal exports over the next 15 years as has been recently projected in a study recently undertaken by BIDPA. The assumptions underlying the projections are that the production for export of steam coal will only occur under a high price scenario and based on the assumption that the appropriate transport infrastructure is developed.

The analysis above suggests that the thermal coal export sector constitutes a substantial potential economic benefit for Botswana. Given current mineral revenues of approximately Pula 12 billion, coal production cannot come to replace diamonds as a source of revenue and the government will need to seek other sectors in order to replace lost revenues. Whether the export revenues will translate into net economic benefits for Botswana will require an assessment of the associated risks and costs associated with the development of the coal export industry.

What a coal export industry will also do is generate significant quantities of discards and middlings. A 90Mt/annum export sector could create a similar volume of middlings and discards. Left unused these constitute a serious source of possible environmental damage but used as feedstock in thermal coal power plants and in coal-to-liquids facility they will be able to replace Botswana’s imports of liquid fuels and develop a significant export industry. In 2010 Botswana imported Pula 4.4 billion of liquid fuels which could be replaced by liquid fuels. As feedstock for thermal power plants this would also permit the development of a commercial energy policy predicated on relatively low cost electricity for energy-intensive down-stream processing activities and possible exports to neighboring countries through the SAPP.

5. Risk Analysis

This section considers the various risks confronting Botswana in the development of a new steam coal export industry. The section considers the important infrastructure issues related to transport water supply and the difficult issue of the of middlings and discards. This is followed by an analysis of the price risks and risks associated with climate change policy at the regional and national level. The shift towards the use of renewable energy now seems to be an inexorable change that will profoundly effect electricity generation over the current century and will therefore effect those exporting fossil fuels such as coal.

• Rail Transport

Botswana has an excellent infrastructure but its rail network is in need of up-grading and improved management. It is generally accepted by both the mining companies and policy makers that the existing rail system either in South Africa or Botswana could not be used to export 90 million tonnes of coal to Maputo, Durban or Richards Bay which are the existing available ports. In part, the problem stems from geography as the existing rail routes require export coal to the Indian ocean coast through South Africa which involves a considerable ascent up the escarpment to the Drakensburg Mountains. The economics of transporting low value to weight products like coal militate against the most geographically direct route.

Botswana Railways suggests prices for the transport of coal to the coast at BWP950/tonne to Durban and BWP 670 to Maputo in Mozambique²⁸. With an estimated run-of-mine price of coal of USD 20-30 per tonne in eastern Botswana (contract thermal coal was sold at BWP 122/tonne in 2010 from MCL to BPC-see WB feasibility study) and a port handling charge of approximately USD 5/tonne this would result in break-even coal FOB price of USD 110-120/tonne to Maputo and USD 150/tonne to Durban. Given export prices are much lower from Indonesia and Australia, the existing rail network and the prices provided by Botswana Railways would render Botswana's exports as commercially unviable. More significantly even if the prices were sufficient to cover such land transport costs the rail infrastructure based on a narrow Cape Gauge train line is such that it would not be capable of handling 90 MT of coal per annum from Botswana that is estimated to be possible within the next decade if a new wider gauge rail line is built²⁹.

Look West?

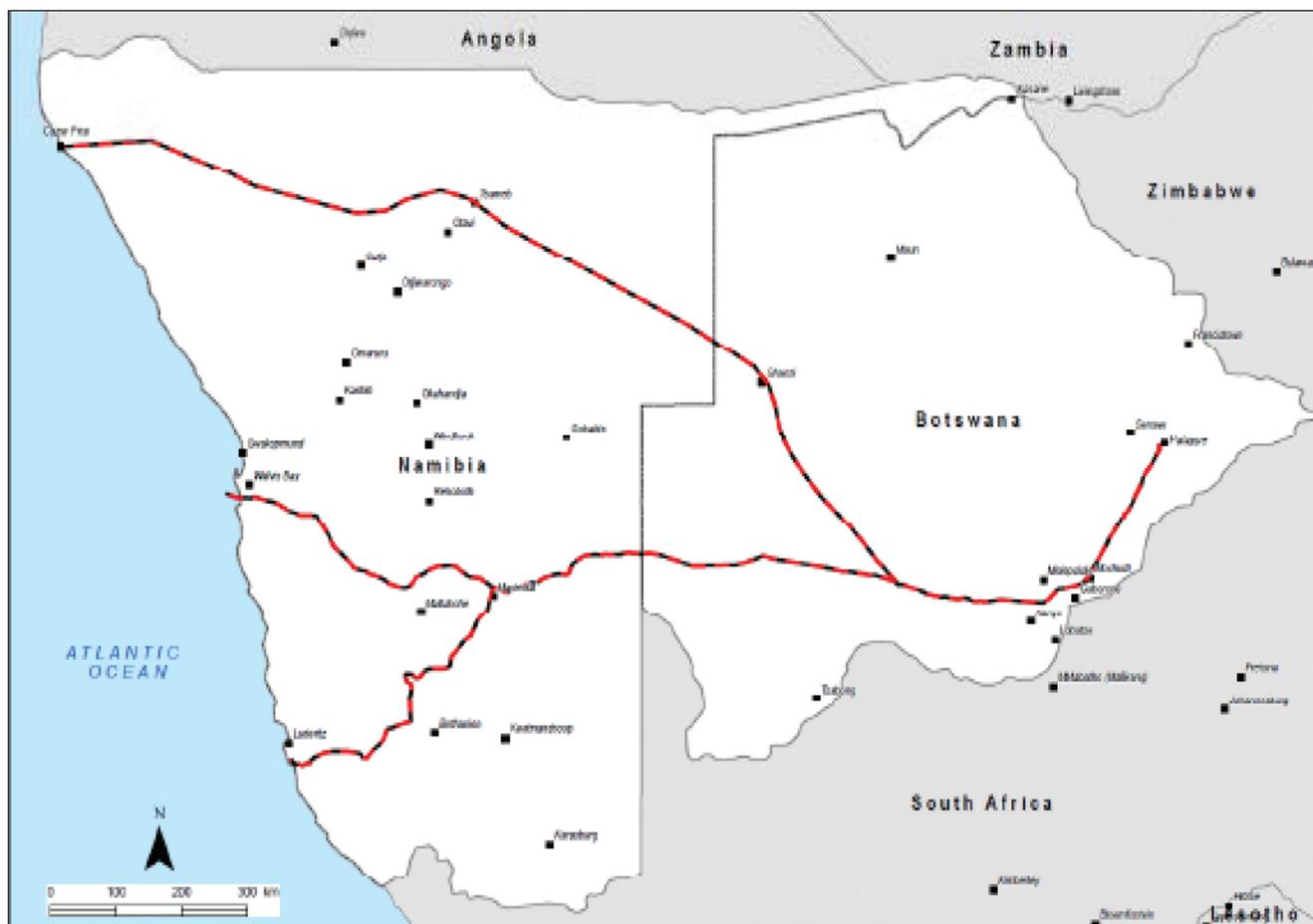
At present there exist at least two potentially competing rail proposals – one to Walvis Bay on the proposed Trans-Kalahari Railway. It is estimated that the capital cost of construction of that route would be approximately USD 10 billion while operational costs are expected to be USD 27 billion for 30 years³⁰. It is expected to take five years to complete and to be built as a PPP (Private-public-partnership). CIC has been its principle private sector supporter. This route has been considered in various coal studies since at least 1974. Both the Trans-Kalahari and alternative routes are proposing a wide gauge 60Mtpa capacity with 30 tonne axle load.

²⁸ Pers com, Botswana Railway. Contract price for coal exports in 2011. .

²⁹ In government statements an export figure of 90 Mt/a is foreseen by government as a feasible level of exports. Pers com Mr BB Paya. Permanent Secretary, Ministry of Minerals Energy and Water Resources, Gaborone at Botswana Coal and Energy Conference 29-30 November 2011.

³⁰ Botswana Integrated Transport Policy –Draft White Paper, Volume 2, July 2011, Page 126

The Potential Routes for the Trans-Kalahari Railway



The benefit of this route is that it would necessitate final agreement with only one other country i.e. Namibia, a country which Botswana has had generally the most cordial of relations since its independence from South Africa in 1990. In recent presentations by the Port of Walvis Bay it has suggested that a completion date for the railway of 2020 is currently expected though there has been no bankable feasibility study completed by the proponents.

The project involves the construction of a heavy haul line from the coalfields in Botswana to the West coast of Namibia at either Walvis Bay or Luderitz. Consultants have been appointed by the governments of Botswana and Namibia with funding from the World Bank to evaluate the pre-feasibility of this link along with the alternative to the east coast along with the Moseitse-Kazangula rail link which would establish rail access to Zambia and DRC. While the government of Botswana is anxious to make use of the dry port facility that has been offered to it at Walvis Bay, there are serious questions as to whether Walvis Bay is an appropriate port for bulk coal exports. At present it does not have the depth to berth large bulk coal vessels and is principally a container port. Its operation as a bulk commodity port will require on-going dredging and while this is possible it will greatly increase costs. Moreover Walvis Bay, remains an important fishing port for Namibia for those operating in the South Atlantic and exports of upto 90Mt of coal per annum could pose a **potential environmental risk** that will have to be evaluated carefully. A further environmental consideration for Namibia is that any route would have to transit some of the country's important national parks and reserves which is a major consideration for the government of Namibia.

The main disadvantages of this route is that it is further from the coal fields of the eastern Kalahari region. However, new potential coal fields in the central Kalahari e.g. Takatokwane, west of the Jwaneng diamond mine are currently being explored. A further disadvantage is that Walvis Bay is on the Atlantic

Ocean adding several days sail to any development on the Indian Ocean side if the target market for coal is in Asia, as is likely to be the case. The very substantial copper/nickel deposits that have been found in the west of Botswana in Ghanzi-Maun corridor close to the Namibian border suggest that there may be more demand for a western rail service than was initially envisaged. The potential iron ore and copper deposits near Shakawe, near the Caprivi Strip, also suggest the commercial advantage of the western route. However, relatively high value commodities such as copper and nickel are normally transported by road rather than rail.

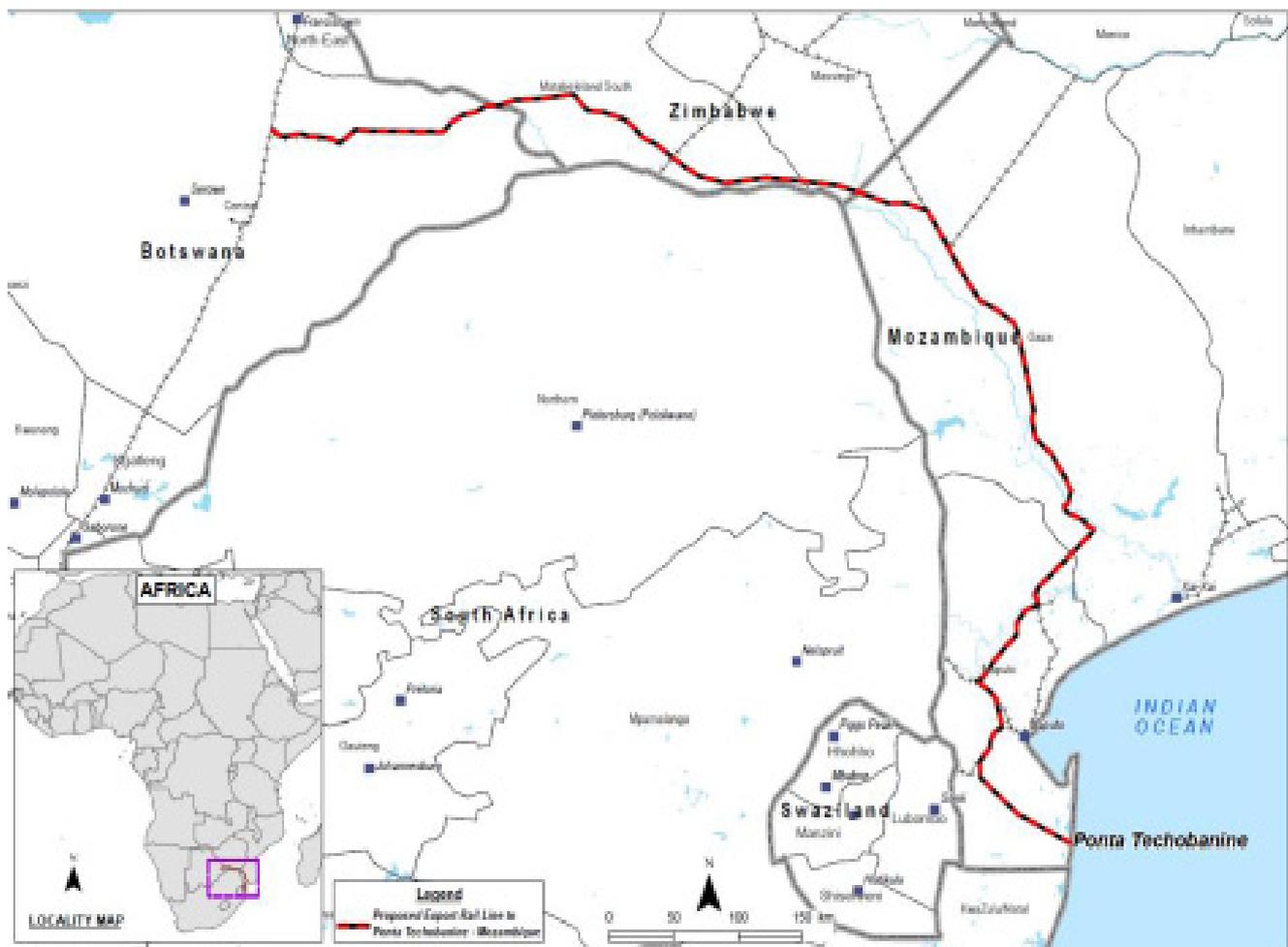
Look East?

One alternative Route is the Ponto Techobanine Corridor through Zimbabwe to Techobanine south of Maputo. This route would cost USD 11.6 billion and would be considerably shorter than the route to Namibia, approximately 1,100 km. Like the trans-Kalahari this is proposing a 60Mtpa capacity with 30 tonne axle load. The route proposed by the private sector proponents of the project would follow the Limpopo valley downhill therefore not requiring the up-hill loads associated with the more direct route across the Waterberg and Drakensberg mountains in South Africa. One of the single most important advantages to Botswana from this route is that the proponents of this route are proposing to use the town of Selebi-Phikwe, the third largest town in Botswana as the staging point for all coal coming from Zimbabwe and Botswana. Selebi-Phikwe has an uncertain future as it is a town almost exclusively reliant upon the BCL Copper Mine which has been operating for 40 years and is expected to close in 20 years. This would provide an important boost to a town that would otherwise go into terminal decline.

In March 2011 the three countries involved in the project signed an MOU to progress its development. The preparatory phase is expected to be completed by the end of 2011 and according to proponents construction is expected to commence in 2012 and end by 2015. Given the ongoing delays these dates are unlikely to be met. A further advantage of this route is that the Ponto Techobanine is a natural deep water port and will not require the extent of dredging in order for bulk coal carriers to dock. A port facility of 200 Mtpa is also expected to be built. Whether such a railway that traverses the Lubombo Transfrontier Conservation Area and the Maputo Elephant Reserve will not be blocked by South Africa because of **environmental risks** is a further consideration³¹.

³¹ The Lubombo Transfrontier Conservation Area covers 4,195 square kilometres (1,620 sq mi), of which 2,783 square kilometres (1,075 sq mi) (66%) is in Mozambique, 1,095 square kilometres (423 sq mi) (26%) is in South Africa, and 317 square kilometres (122 sq mi) (8%) is in Swaziland. The Maputo Elephant reserve locally known as Reserva Especial, this 1,040 square kilometres (400 sq mi) reserve is situated in the southernmost part of Mozambique, 79 km south of Maputo, in the province of Maputo. It is bounded on the east by the Indian Ocean, and on the west by the Rio Maputo.

Route of Ponto Techobanine Railway



The other risks associated with the easterly route is that it would expose Botswana's exports to the **potential sovereign risk** of a transit via Zimbabwe. This would mean that exports of what would become one of Botswana's main mineral products could be halted in the event of tensions which have existed in the past. This sovereign risk is in part mitigated by the proposal to use Selebi-Phikwe in eastern Botswana as the hub for the railway network. This would mean that the high quality coking coal coming from Sengwa, in Northern Zimbabwe would have to transit Botswana en route to the port at Techobanine. Thus both countries would be dependent upon free access across each others borders in order to allow coal to be exported to Mozambique.

The route from the main coal deposits in the east of Botswana on the eastern edge of the Central Kalahari Karoo Basin is where the highest quality coal deposits in the country are found and the ones most likely to be developed at the beginning of coal mining for the export market. This suggests a route to Mozambique down the Limpopo valley which would involve the lowest inland transport cost. Indeed the work of Botswana scholars on the matter confirms the commercial and economic superiority of the route to the Indian Ocean³². Unless a clear and obvious market exists for Botswana coal in the otherwise stagnant European coal market, which should not be entirely discounted given the shift away from nuclear power, then the obvious route from a purely commercial standpoint is to the Indian Ocean which would not involve such long transit but would involve the government in sovereign risk considerations.

³² Fichani, K. and Labys, W.C. (2006) 'Planning the future of Botswana's coal', Int. J. GlobalEnergy Issues, Vol. 25, Nos. 1/2, pp.60–82.

Another easterly option proposed by the existing railway parastatals is that they be responsible for an easterly route using existing railnetworks through Zimbabwe and Mozambique. The difficulty with this option is that existing networks use the narrow Cape gauge which would be unlikely to carry very substantial amounts of coal reliably over a protracted period of time. The impact of this approach while potentially requiring a lower capital cost it could increase the delivery risk associated any future coal contracts.

A final significant option is not to develop the railway link and to simply extend a spur for the Waterberg coal fields in South Africa through to Mmamabula and Morupule. While this is a potential option for Botswana it would leave the country dependent upon exports though Richards Bay which has a maximum throughput of approximately 90 Mtpa. This would not be able to accomodate Botswana's planned exports without a significant expansion.

• Water

A significant component of any assessment of Botswana's increased dependence on coal exports must include the vital question of water availability and alternative uses of water in agriculture in a very arid country like Botswana. Export quality coal in the volumes required to make a new rail network viable will also require substantial volumes of water. Water for most mines in Botswana at present rests very largely on the use of water from boreholes drawing down on what are unknown water resources at what are accepted as unsustainable levels. As a result, government policy towards abstraction of ground water is quite clear especially when it is for purposes other than those defined as 'vital purposes'. The Botswana National Water Management Plan Review (2006 Executive Summary, p.13) states clearly that:

'The total sustainable abstraction (of ground water) is barely enough to supply Gaborone alone. The use of groundwater other than for vital purposes (potable supply, livestock) from major aquifer units should not occur. The only reliably recharged and sustainable resource is from the sand rivers.'

Coal mining and its associated uses requires water for several purposes:

- Cooling demands for the plant and equipment in the mine
- Dust suppression in the mining operations and associated conveyer systems
- Consolidation of roadways in the mine
- Cleaning of mechanical plant and equipment
- Washing of run-of-mine coal in preparation for export or domestic thermal energy generation³³

The demand for water stemming from coal mining is considerable. In the case of Morupule Colliery the expansion that is envisaged to get from its current levels of output of less than 1Mt per annum to expanded domestic production and exports of 12 Mt will require a substantial increase in the water usage³⁴.

³³ Coal Washing is part of a broad group of technologies that aim to reduce the adverse environmental impacts of generating energy from coal. The technique involves washing the coal to remove it of its impurities before it is burned for energy combustion. Coal is first ground into smaller pieces so that it can be more easily processed. The pulverized coal is then washed in water or in fluids with densities that cause the coal to float so that unwanted impurities can sink to the bottom. Coal washing reduces the ash content of coal by over 50%, resulting in less waste.. About 25% of the sulfur content is reduced, lowering the amount of sulfur dioxide emissions released upon combustion. This in turn decreases but does not necessarily eliminate the occurrence of 'acid rain'. Coal washing also improves the heating value of coal, known as the thermal efficiency, which reduces carbon dioxide emissions as well..

³⁴ Debswana, Morupule Colliery Expansion Project, Final Environmental Impact Statement, Volume 1, December 2008, p.xiii <http://www.mclexpansion.com/images/EIA/Vol%201/Vol%201%20Draft%20EIS.PDF> downloaded 25th November 25, 2011' There will be increased use of power from the present 2.5 MW/annum to approximately 36 MW/annum and increase in water use from 74, 400 m3/annum to 959 400 m3/annum.

Like all mines in Botswana, the Morupule Colliery has historically relied upon bore holes for most of its water supply which is unsustainable given the low rates of replenishment of artesian sources. However, as part of its expansion the mine has built a 17 km water pipeline that links the North-South Water carrier which is in turn supplied from renewable surface water. While it will continue to rely in part on ground water it is increasingly relying on water from Water Utilities Corporation.

If one takes the Mmamabula deposit the expected exports from the mine, when in full operation are in the vicinity of 23 Mt/a. According to company estimates the amount of water required for such an operation is in the vicinity of 10.5 Mm³/a for a period of 35 years. This means that a coal export industry of 90 Mt/a as envisaged by government, will require approximately water 41 Mm³/a. The on-going abstraction of such large volumes of ground water is, from a national standpoint probably unsustainable. The management of CIC energy, the current owner of the Mmamabula resource indicates that the water, unlike Morupule colliery will come from artesian sources through bore holes and will be brackish water³⁵. Under current Botswana laws abstracted ground water incurs no marginal cost except the cost of pumping³⁶. Recent US reports on water usage in US coal mining suggest that increased mining activities will place ever greater pressure on scarce water resources³⁷.

It is the intention of the government of Botswana to abstract some 495 Mm³/annum from the Zambezi in the coming years in order to assure adequate supplies for both domestic use and for irrigation. However, if mining is to move away from the current unsustainable practice of ground water abstraction then it will also need to make use of the surface water from the Zambezi. With ground water provided gratis it will prove very difficult to wean the mining sector off their current unsustainable practices and moreover it will prove extremely difficult for Botswana to raise the substantial loans needed for such a large infrastructure project (see appendix 1 for a more detailed discussion of mining water demand and pricing policy).

While it is essential as part of sustainable water strategy, the pricing of large volume abstraction of ground water cannot be seen as a permanent solution to Botswana's water supply issues. It is however a vital part of a more rational use of one of the nation's scarcest natural resources. Only a national water grid providing water from the Zambezi to most major settlements as far as Ghanzi would be able to supply both the population and the mining industry with sustainable supplies of water. The revenues generated from pricing water abstraction can provide part of the resources needed for such a major national undertaking.

The development of a sustainable coal export industry requires two vital pieces of national infrastructure. First a national water grid using water abstracted from the Zambezi combined with a wide gauge railway to either the Atlantic or Indian Ocean coasts. These projects are *conditio sin qua non* for a 'sustainable development' of the coal export industry.

³⁵ Pers Com, Mr Greg Kinross, President CIC Energy, 30th November 2011.

³⁶ WUC pumps ground water at an average cost of P2/m³ though drilling companies suggest that much lower costs are possible of approximately P1.5/m³

³⁷ US Department of Energy (2006) Emerging Issues for Fossil Energy and Water Investigation of Water Issues Related to Coal Mining, Coal to Liquids, Oil Shale, and Carbon Capture and Sequestration, DOE/NETL-2006/1233 page 11

'Estimates of water requirements for mining activities range from 10 gallons per ton to more than 150 gallons per ton of coal mined, with the lower range applicable to western coals with minimal revegetation activities and the higher end applicable to underground mining of eastern coals. Recycling of water in underground mining process can dramatically reduce water consumption. Coal washing is applicable to eastern and interior coals, while western coals are typically not washed due to homogeneous seams with low sulfur content.....Water requirements for coal washing are also quite variable, with estimates of roughly 20–40 gallons per ton of coal washed'

• The use of Middlings and Discards

The coal washing and preparation process will be absolutely necessary for the development of an export industry with quality up to an international standard³⁸. This requires not only water but serious consideration of the use of waste from both the mining and washing process. This is important for not only environmental reasons but also in terms of the profitability of mines. The processing of coal results in a number of by-products of varying degrees of economic use and environmental risk. The most valuable are middlings which are commonly used in domestic power generation as well as in the production of coal to liquids³⁹. There is also the production of waste referred to as discard⁴⁰ and 'duff'⁴¹. In South Africa, with an export industry of 70 Mt per annum, there is an accumulation of some 60 Mt per annum of discard which has resulted over time in a 1 billion tonne stockpile⁴². This not only poses a considerable environmental challenge for South Africa and similarly for Botswana in future, but it also constitutes a potentially valuable resource that can be used for power generation using fluidized bed combustors⁴³. However, it should be noted that this resource diminishes in quality over time.

The coal washing and preparation process also produces what are with current technologies, an unusable waste called 'Blackwater' which contains significant quantities of heavy metals and in some cases carcinogenic materials⁴⁴. Given current technology Blackwater cannot be returned to the environment and has to be kept in permanent containment areas. The creation of large accumulations of discards will also create the possibility of acid mine drainage⁴⁵. This is not as likely to be a problem in Botswana due to the country's aridity. A further difficulty associated with coal mining generally and discarded coal mines is the incidence of coal fires which have been known to continue for many years⁴⁶.

In the event that Botswana develops a coal export industry which exports 90 Mt per annum of export quality coal then this could create coal middlings and discards of a similar quantity. In large coal exporting countries like Australia, South Africa and Indonesia there are substantial thermal coal powered facilities which provide a source of demand for such relatively low quality coal. This is in large measure because all these countries have either very large populations or are relatively developed and therefore require

³⁸ The regional standard is RB 1 or RB 2. RB 1 is defined as coal with the following qualities including calorific value: basis 6 000 kcal/kg NCV, minimum 5 850 NCV; total moisture: maximum 12% (as received basis); volatile matter: minimum 22% (as received basis); ash: maximum 15% (as received basis); sulphur: maximum 1.00% (as received basis); - hardgrove grindability index: 45-70 (typical, and not to be used for determining whether or not a shipment complies with the specification); - nominal top size: 50 millimetres; ash fusion temperature (initial deformation): minimum of 1 250 degrees Celsius in a reducing atmosphere; - calcium oxide in ash: maximum 12% (dry basis). It should be noted that even after washing a significant portion of the coal produced in Botswana is below RB 2.

See <http://www.keatonenergy.co.za/g.php>

Botswana's coal is of a relatively low calorific value. It is doubtful that even following washing that Botswana coal will reach the calorific values of RB 1 but will nevertheless have a market in Asia.

³⁹ In South Africa approximately one third of coal used in electricity generation comes from middlings in the coal washing process and the other 2/3 from screened run of mine production.

⁴⁰ Duff is defined as Coal of square mesh screen size less than 6.3 mm. *ibid*

⁴¹ Eberhard A. (2011) *The Future Of South African Coal: Market, Investment, And Policy Challenges Program On Energy And Sustainable Development*, Stanford University, Working Paper No100, page 5

⁴² Eberhard A. (2011) *The Future Of South African Coal: Market, Investment, And Policy Challenges Program On Energy And Sustainable Development*, Stanford University, Working Paper No100, page 5

⁴³ FBC technology has proven to be suited to burning fuels that are difficult to ignite, like petroleum coke and anthracite, low quality fuels like high ash coals and coal mine wastes, and fuels with highly variable heat content, including biomass and mixtures of fuels. This opens the possibility of using discards and duff as thermal fuel. See http://www.fossil.energy.gov/programs/powersystems/combustion/Fluidbed_prog031.pdf downloaded 20th June 2012.

⁴⁴ See EPA/DoE (1979) 'Characterization of Solid Constituents in Blackwater Effluent from coal preparation Plants, Washington' <http://nepis.epa.gov/Exe/ZyNET.exe/9100R9B1.TXT?ZyActionD=ZyDocument&Client>

⁴⁵ See Technical Report: Acid Mine Drainage Prediction (PDF) (52 pp, 181K, About PDF)

This technical document provides a brief review of acid forming processes at mine sites, a summary of the current methods used to predict acid formation, selected state regulatory requirements, and case histories (December 1994, EPA 530-R-94-036). http://water.epa.gov/polwaste/nps/acid_mne.cfm

⁴⁶ Pone, J.D.N., et. al., 2007, The spontaneous combustion of coal and its by-products in the Witbank and Sasolburg coalfields of South Africa: *International Journal of Coal Geology*, v. 72, p. 124-140, see also Stracher, G.B., ed., 2007a, *Geology of Coal Fires: Case Studies from Around the World: Reviews in Engineering Geology*, v. XVIII, doi: 10.1130/2007.

large volumes of low quality coal for the domestic electricity market. However, this is not the case in Botswana. The current total estimated growth in electricity demand to 2020 in the country may require a further 600 MW ⁴⁷.

It is entirely possible that if Botswana were to pursue a policy of providing relatively cheap electricity for the down-stream processing of base metals then this would add significantly to the required electricity throughout the remainder of the decade. However, it is highly unlikely that such a development would consume more than a further 3 million tonnes of coal domestically. This would not provide a sufficient demand for the volumes of middling and discard coal that would be generated by an export industry. Given the existence of the Southern African Power Pool (SAPP) it may be possible for Botswana to export electricity using this coal as feed stock. The difficulty is that the largest market, South Africa also has large volumes of middlings and discards from its coal industry and would not import either coal or electricity as it would diminish the profitability of local mining companies. Small volumes of electricity could, in theory, be exported to Namibia but that would not be sufficient to absorb the volumes of coal that would be stockpiled from an export industry. Moreover, since the cut of electricity supply from South Africa post-2008 more countries in the SADC region have become wary of dependence on imported electricity.

One possible coal beneficiation proposal would be to use discards and middlings for a coal to liquids (CTL) project which would use the available resources from the coal export industry to produce liquid fuel. In the US, estimates suggest that CTL technology could readily produce petroleum products at oil prices well below existing levels⁴⁸. However, even such a proposal is not without considerable external costs that need to be factored into the planning of the development of the sector. Unless there is a carbon capture and storage program associated with such a proposal then it usually results in higher GHG emissions than burning oil⁴⁹. Perhaps more significantly with the exception of the Sasol coal to liquids program which was heavily subsidized over many decades by the South African government⁵⁰ there have been few attempts at commercial CTL projects in the world. China⁵¹ is currently working to develop CTL but this has been done with US technology and the assistance of the US Department of Energy⁵².

Sasol which is without doubt the most commercially successful user of CTL technology has for a number of commercial reasons moved its strategic commercial interests away from CTL technology and over 2011 abandoned two large CTL projects in China⁵³ and Indonesia⁵⁴. While continuing work on a feasibility study for a JV for a CTL facility with Tata in India, Sasol has increasingly shifted to using gas-to-liquids technology which is more acceptable in many countries and with an increased cleavage between natural gas and oil prices is becoming increasingly profitable.

⁴⁷ See www.capital.bw/resources/presentations/botswana_power_corporation.pdf downloaded June 2012 for demand projections for Botswana by BPC

⁴⁸ 'Fisher Tropsch (Sasol) liquids could compete with oil at a crude oil price of \$41 to \$61/ Bbl depending on plant size, coal type (bituminous v. lignite), and financial assumptions.

http://fossil.energy.gov/programs/reserves/npr/Coal_to_FT_Liquids_Fact_Sheet.pdf downloaded 22 June 2012.

⁴⁹ It is estimated in the US that CTF technology generates 1.8 more GHG than oil refining and is therefore amongst the most polluting sources of fossil fuels. Source *ibid*

⁵⁰ 'The South African Government, however, continued its investigations into the feasibility of developing an oil-from coal venture and formed a state-owned enterprise in 1950, the South African Coal, Oil and Gas Corporation (later to be renamed Sasol). Extensive government support at the time – and, again during the 1970s and 1980s – was essential for the establishment of what is still the only commercial coal based synfuels industry in the world.'

http://www.sasol.com/sasol_internet/downloads/CTL_Brochure_1125921891488.pdf

⁵¹ Two companies in China are developing CTL facilities including Shenhua Group Corporation Ltd and Ningxia Coal Industry Co Ltd (Ningmei).

⁵² Shenhua Coal to Liquids Plant, China 'The first phase of the facility opened in July 2009 and employ US-developed technology from Headwaters Inc and Hydrocarbon Technologies Inc (HTI) in conjunction with West Virginia University and the US Department of Energy' <http://www.hydrocarbons-technology.com/projects/shenhua/> downloaded 22nd June 2012

⁵³ <http://www.bloomberg.com/news/2011-09-12/sasol-reallocates-china-funds-staff-after-delay-getting-project-approval.html> downloaded 22nd June 2012

⁵⁴ See 'Sasol halts Indonesia coal-to-liquids plant project' <http://www.reuters.com/article/2011/01/18/sasol-indonesia-idUSLDE70H0W820110118> downloaded 22nd June 2012.

While Botswana's options for a strategic partner in the use of its middlings and discards from the export industry are limited the country is not exclusively confined to the option of using Sasol as a strategic partner. China, with assistance from the US is developing its own technological capacity and while the application of the technology in China is relatively new the evidence suggests that profits are being earned. Therefore Botswana could seek assistance from the US which helped China to develop its own CTL facilities.

One factor that Botswana will need to consider is the very significant volumes of water that will be required for a CTL plant. The Sasol plant uses approximately 6-7 litres of water for each litre of liquid fuels⁵⁵. It should be noted that even with Sasol's water recycling the Fisher-Tropsch technology used by Sasol is known to be highly water intensive⁵⁶. However, modern CTL air-cooled technologies exist which use 1.5 litres of water per litre of liquid fuel produced.

• Price Risk

The rising global demand for coal creates a major and substantial opportunity to diversify the Botswana economy away from its near total dependence on diamonds. However, this will shift the economic dependence of Botswana away from diamonds to coal in the post-2030 era when a very significant portion of Botswana's known open-cut diamond deposits will in effect be exhausted. Historically, of all the fossil fuel sources, the coal price was amongst the most stable, especially when compared to that of oil and gas. This is certainly no longer the case as can be seen in the figure below.

The development of the coal deposits will also link Botswana's economic growth more closely to that of India⁵⁷ in the coming years as it is the closest of the major coal importers though recent prices do not preclude exports to more distant markets such as South China. This is because Botswana remains one of the very few remaining politically stable and commercially significant green fields coal provinces⁵⁸. It is possible that if CIF prices continue to rise in Southern China then China may also become a market for Botswana coal but given the increased interest of Indian investors in Botswana mining assets it is likely that existing supply will be tied to Indian firms with supply contracts with electricity utilities. This would leave Botswana little option but to supply one market and therefore to tie its economic development to the prosperity of that country.

While the risks of dependence on one market should not be underestimated when that market is booming it can be extremely beneficial as Australia discovered during the 2008/9 international economic crisis. Australia's failure to dip into a recession was attributed in large measure to being the principle mineral and coal supplier to China and hence linking Botswana to the booming Indian economy may have similar effects. It should also be noted that during the 2009/2010 Chinese coal price boom Columbia was exporting coal in significant quantities to Southern China and therefore such long distance sea borne trade over these sorts of distances, once unthinkable, have proven commercially feasible.

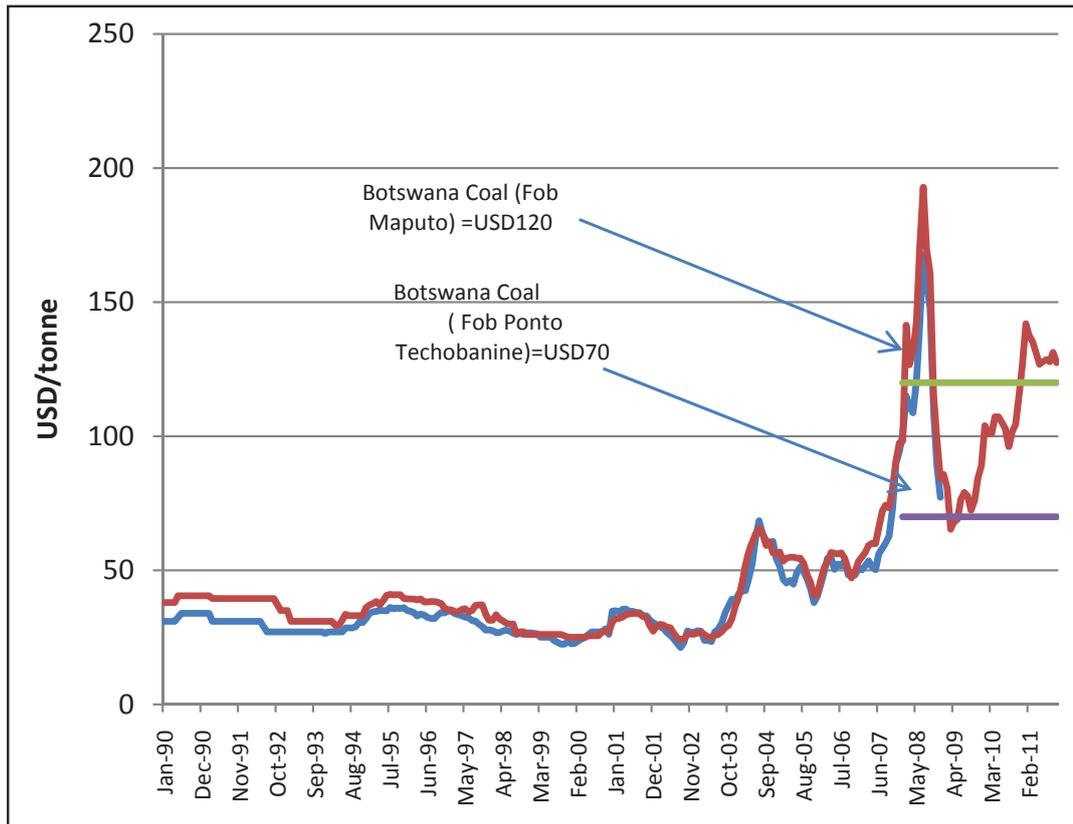
⁵⁵ 'Mr André Steynberg, (Technology Manager for Coal-to-Liquids Technologies, Sasol Technology (Pty) Ltd) replied that water consumption was typically between one and two cubic metres per tonne of coal on a dry, ash-free basis. motor fuel yields from Sasol's indirect process of about two barrels of oil products per tonne of coal on a dry, ash-free basis' International Energy Agency, Coal Industry Advisory Board 'Coal-To-Liquids An Alternative Oil Supply?' Workshop Report , November 2006. P. 10 http://www.iea.org/work/2006/ciab_nov/workshopreport.pdf downloaded 28 June 2012

⁵⁶ Sasol Sustainable Development Report 2011' Our total water demand for 2011 has increased slightly from 2010 at 151,0 million m3 to 152,5 million m3 in 2011. Our total quantity of water recycled for the 2011 financial year was 128,7 million m3.'

⁵⁷ 'India offers to develop Botswana's rail network' India has offered technical assistance to develop and strengthen rail network and other mode of transportation in the southern African country of Botswana. Minister of State for Commerce and Industry Jyotiraditya Scindia offered Indian assistance during a bilateral meeting with Botswana's Vice President Mompoti S. Merafhe Monday night here, a statement from the ministry said Tuesday.. Date: 21 September 2011 Source http://twocircles.net/2011sep20/india_offers_develop_botswanas_rail_network. downloaded 15th November 2011

⁵⁸ In mid- 2011 negotiations with Indian energy producers JSW to acquire CIC energy, the developer of the Mmambula deposit , broke down. Botswana's resources are increasingly being explored by small and medium Australian and Canadian companies and eventually be sold to much larger developers. See Wall street Journal June 1, 2011, 7:42 A.M. ET 'JSW Energy Scraps Plan to Buy CIC Energy <http://online.wsj.com/article/SB10001424052702303657404576358740500369376.html> downloaded 25th November 2011

Australia and RSA Steam Coal Prices Compared to Hypothetical Botswana Price



Source: IMF and author's calculations

The chart above shows SA and Australian prices over the last thirty years compared to the estimated hypothetical Botswana fob prices for coal over the last three years. Certain facts are worthy of consideration. The first is that the price of coal was very stable in the 1980's and 1990's. However, since coal has become more internationally traded over the last ten years and has been increasingly in short-supply given the rising global demand described above steam coal prices have not only shown greater volatility but also a closer association to other fossil fuel prices than was the case in the past. As the figure shows while stability of the past was commendable it meant that prices were generally below levels that would justify the construction of a railway to the Atlantic or Indian Ocean coasts. It is only in the wake of the most recent coal price boom that such railway construction is viable. Prior to that prices were too low to justify the construction of a railway.

Given the increased volatility of global steam coal prices Botswana would not be viable as an exporter if exporters were to rely on existing rail corridors and the ensuing quoted prices even if those rail links were able to handle more than 2-3 million tonnes without substantial delays. Botswana coal would only have been viable at the peak prices found during the 2007-2008 boom. With a new railway and the dramatically decreased freight costs associated with such a dedicated service it would be possible to export at Fob Maputo prices of USD70-75/tonne which would mean that Botswana would be able to withstand increased price volatility in the steam coal market.

The Economics of Electricity Generation

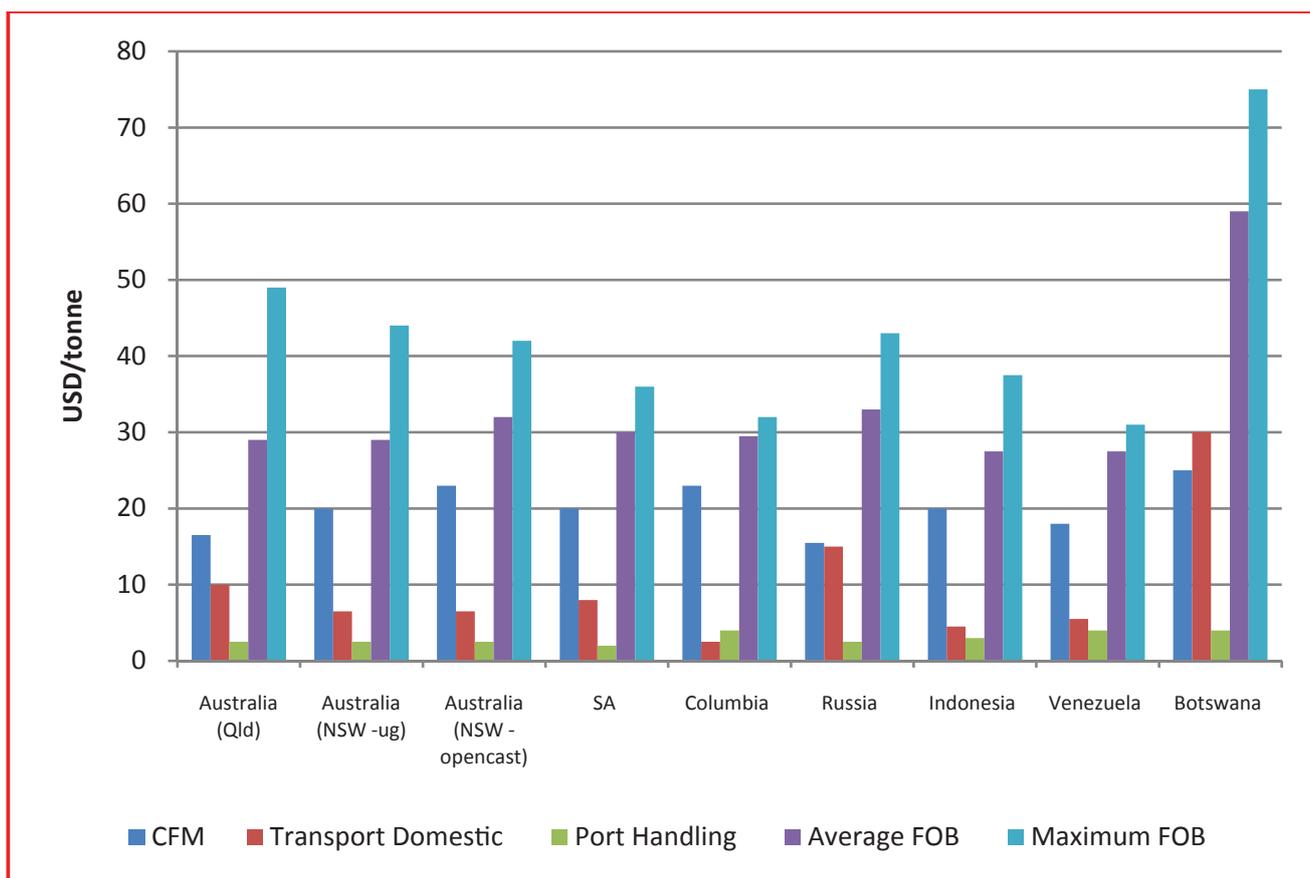
A typical 600 MW thermal power generating facility such as Moropule B requires some 3 million tonnes of coal per annum. Due to factors such as location the cost of constructing such a facility in Botswana costs in the vicinity of USD 1.2-1.4 billion, considerably higher than capital cost estimates in other regions. The plant can be reasonably expected to have an economic life of at least 30 years. Investment costs in such plants normally represent around 50% in most cases. O&M cost account for some 15% and the total and fuel costs for some 35%. In Botswana the washed coal price for Morupule B is in the vicinity of USD38/tonne. 'Each ten percent fall in the price of coal from BWP 250/tonne (US\$38.3/tonne) increases the economic rate of return (ERR) for Morupule B by 0.32 percent.' Thus even fairly substantial coal price increases will have very limited effects upon the rate of return.

Source: World Bank 2009, Moropule B Feasibility Study op. cit and IEA study 2010 <http://www.iea.org/textbase/npsum/ElecCostSUM.pdf>

Using the case of Moropule B, which is in many ways a very typical thermal power station the rate of return on the investment is not highly sensitive to the price of coal. The greater the discount rate the less sensitive is the rate of return to fluctuations in the coal price. The reason is because so much of the cost of generating electricity is to be found in the cost of constructing the facility. As a result, price fluctuations are unlikely to significantly affect coal demand in the short run. In the longer term however as new decisions over technology and plant are made coal prices will become far more important. As we shall see below it will take very substantial increases in the price coal to effect the decision of electricity generating companies to close or abandon existing plant in favor of a new technology.

The figure below compares the components of unit fob price for Botswana coal at the Mozambique coast compared to unit FOB prices for other major suppliers. Based on the estimates of the high cost of production, transport and port facilities which were provided by the private sector, Botswana would almost certainly be the marginal swing producer with the highest unit cost of coal of all major exporters. Given the coal prices currently available globally Botswana's export costs would not preclude it from trade but in the event of major cyclical price fluctuations, which as mentioned above, have become more frequent on the international coal market, it would be Botswana exporters that would be amongst the first to experience a decline in orders and the last to reenter the market when an up-turn commences. This will have implications for the macroeconomic stability of the country.

Unit CFM, Rail, handling and FOB prices of coal of Major producers (2009)



Source: Industry sources and author's calculations

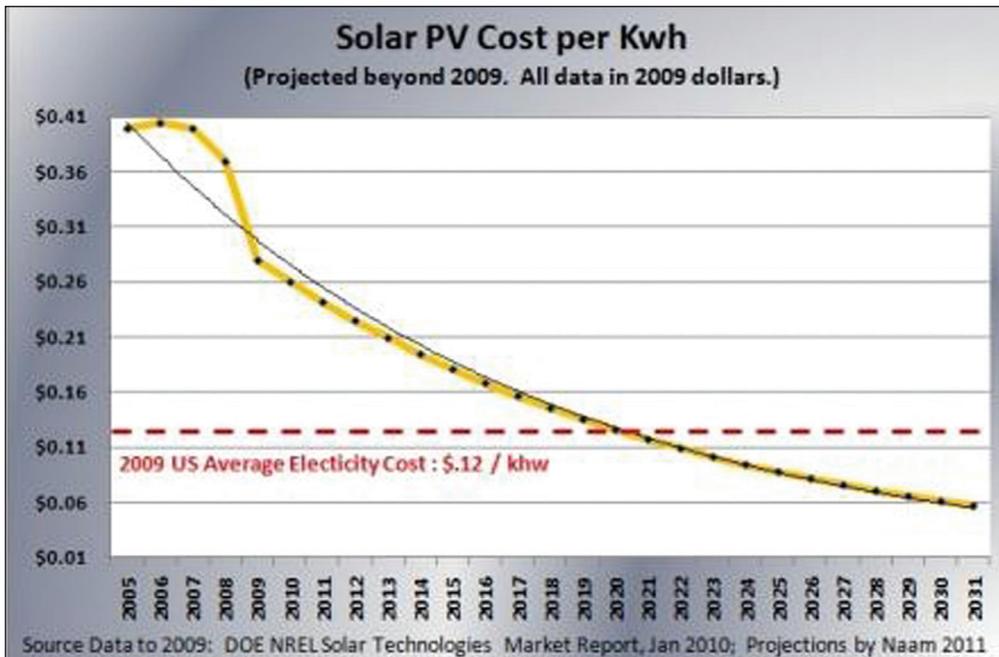
• The Climate Change Debate and the Future of Coal

What follows is based on the assumption that an effective international climate change convention that drives, rather than follows the pace of national GHG emission reductions of major emitters, is not possible for the immediate future. Given the conflicting commercial and sovereign interests of countries involved in forging such a consensus what would emerge from global negotiations can only be a weak compromise especially given the surging demand for coal and other fossil fuels from China and India. While it is reasonable to assume that for political reasons countries will eventually come to agreement at some point on a treaty that will appear to reduce GHG emissions the treaty will have at best only the most marginal impact in terms of disciplining the significant emitters. This is not to suggest that there will not be efforts at GHG emission abatement which is continuing at a national and regional level but rather that it will stem from initiatives of individual countries and from technological change currently occurring in the electricity generation sector. We consider below two related issues that Botswana needs to consider in its planning process as it moves towards greater dependence on steam coal export.

a. Technological Change and Economies of Scale

The most important factor likely to give rise to a reduction in GHG emissions is the change in relative price of electricity generated from various sources. This can occur through changes in relative price caused by either technological factors being fed through the prices of electricity or through individual taxation regimes which impose taxes on carbon and on non-renewable energy sources. The choice of technology employed for generating electricity is decreasingly a result of simply cost factors and government policy on specific renewable energy technologies e.g. wind and solar as well as on domestic

sourcing of energy has increased the incentives to expand renewable energy generation⁵⁹. While these technologies have been in existence for a considerable period of time, wind is now cost-competitive in many locations without subsidy and solar will likely be so by the end of the current decade. Indeed the pace of cost decreases of solar energy as well as its storage suggests that ‘grid equivalence’⁶⁰ may be reached before the end of the decade. However, the issue of solar power and its ability to replace more traditional forms of power depends in part on its ability to supply base-load which in turn rests on the cost of electric storage. What has driven the exponential decline in the costs of solar power has been both economies of scale and rapid technological change in the industry.



There have been very rapid changes in the cost of electricity generated from both solar and wind power. Indeed on-shore wind farming now has a levelized cost structure that is not significantly different from that of traditional coal fired thermal facilities. More significantly solar power also appears to be rapidly decreasing in terms of levelized cost. In the US it is estimated that the rate of cost decrease of the real cost of solar is approximately 7% per annum⁶¹. As can be seen from the data above there is increasing evidence to suggest that by 2020 solar prices will, if the current rate of cost decrease continues will be lower than conventional grid sources of coal and gas. The decrease in these solar energy costs are now very much part of mainstream energy planning in the US and other developed countries⁶².

This conforms to what is increasingly a mainstream view that by the end of the current century most of the world’s energy needs will be provided predominantly by solar power. It is the levelized capital costs that are the greatest source of cost disadvantage for most forms of energy and there have been a series of

⁵⁹ The most recent scientific estimates of the change in the levelized cost of electricity suggest that concentrated solar power is likely to become a low cost source of energy in the current decade.

Concentrated solar power (CSP) harnesses the sun’s thermal energy to produce electricity. It has been deployed globally since the 1980’s and is currently undergoing a resurgence, particularly in Spain and California, due to its inherent advantages, which are:

- Its potential to become a low cost technology and reduce its levelised cost of electricity (LCOE) from around \$225/MWh currently to \$135/MWh by 2020 (assuming the improvements identified in US roadmaps are achieved). Improvements below \$100/MWh are technically feasible by moving to novel high temperature thermodynamic cycles and new low cost approaches to field design;
- Its unique ability to be integrated with low cost thermal storage to provide renewable power well into the evening demand peak. Storage capital costs are expected to decrease from around \$90/kWh today to \$22/kWh by the end of this decade;

Jim Hinkley et al. (2011) ‘Concentrating solar power – drivers and opportunities for cost-competitive electricity’ CSIRO, Canberra, page 5

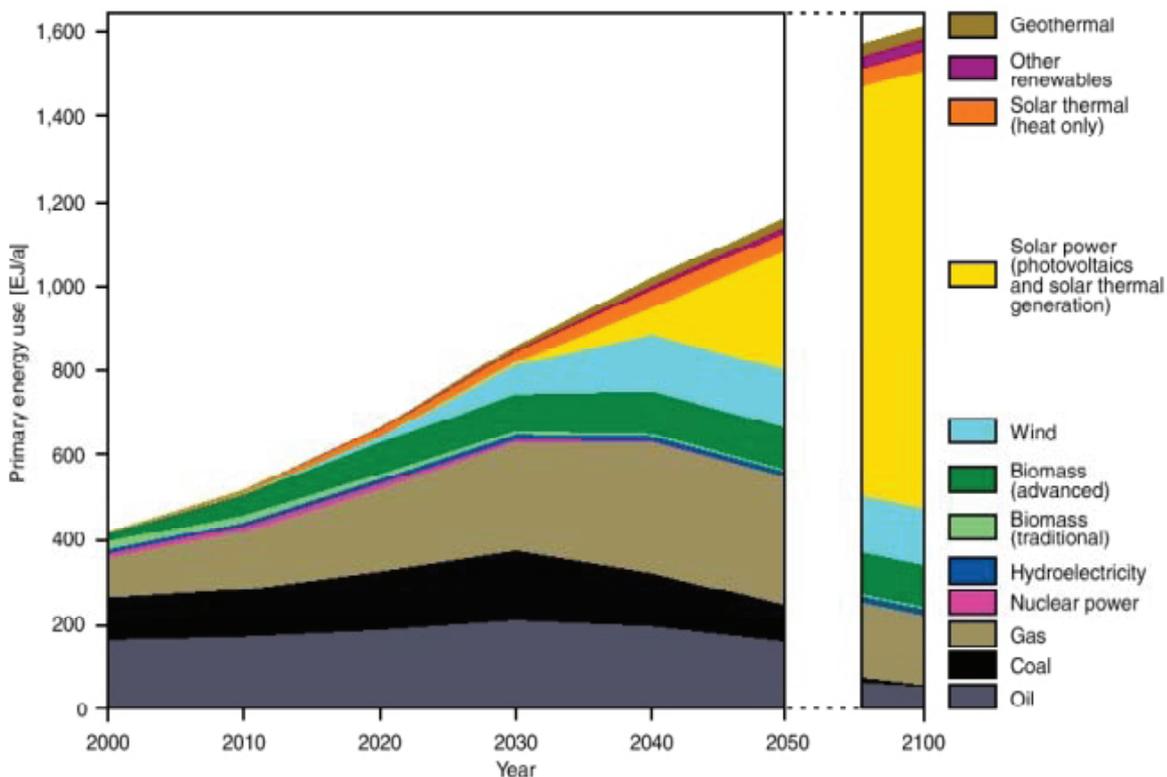
⁶⁰ Grid equivalence is defined as the cost per kWh of electricity equivalent to that which can be bought from the traditional sources ie coal, gas and hydro-electricity of the electricity grid.

⁶¹ <http://blogs.scientificamerican.com/guest-blog/2011/03/16/smaller-cheaper-faster-does-moores-law-apply-to-solar-cells/> downloaded 25th November 2011

⁶² Hinkley J, et. al ‘Concentrating solar power – drivers and opportunities for cost-competitive electricity’ CSIRO, Canberra, March 2011

policies put in place by governments including that of the US, EU and China to promote solar energy and the development of photovoltaic energy. In 2010 the World Energy Council (WEC) concluded that by 2100 oil, gas and nuclear will provide less than 15% of world energy consumption while solar thermal and photovoltaics will supply about 70%⁶³. At present the levelized cost of new generating capacity of electricity by various sources in the US shows that photovoltaics (USD 210/mWh) are still twice the cost of conventional coal (USD 95/mWh) but this varies significantly by region⁶⁴. On shore wind power (USD 97/mWh) is already cost competitive with coal and explains why countries such as China have moved rapidly to expand wind power generation rather than solar.

Projected Global Energy Mix (2000-2100)



Source: WBGU, 2003 World in Transition - Towards Sustainable Energy Systems, German Advisory Council on Global Change, Berlin, 2003 www.wbgu.de quoted in World Energy Council op. cit. p 409

Similar initiatives though few as vigorous have been used in Europe which have provided further incentives to renewable in general and solar power in particular. The mix of policies to provide both explicit support to solar and wind power as well to tax as has with greater or lesser success resulted in an embryonic rise in solar energy generation since the beginning of the century. While the technology of both solar power and wind are driving factors in the application of these renewable sources of energy the expansion of scale has been an extremely important factor in driving down solar prices.

Why this is significant to Botswana is that the very economic forces that raise coal prices simultaneously increase the relative competitiveness of competing renewable alternatives such as solar. The policy risk for Botswana is that the pace of technological change is never known a priori and is rarely smooth. The adjustment to sustainable energy expected in the current century, if prompted by government policy may be more rapid than expected and hence any late and high cost entrants into the global coal market may find their position exposed. In mitigation the coal importing countries which will be the main targets markets for Botswana's coal i.e. India and China are continuing to expand the

⁶³ World Energy Council, '2010 Survey of Energy Resources' op.cit p.409.

⁶⁴ US Department of Energy, Energy Information Administration, 'Annual Energy Outlook 2011' December 2010 DOE/EIA -0383

number of coal fired thermal plants which can be expected to have a life of 30 years. This will mean that thermal plants being commissioned over the current decade will continue to demand coal to well past what most observers see as peak coal in 2030-2050. While demand for coal will continue what cannot be assured is that as demand starts to swing towards lower cost forms of electricity generation in the 2020's and 2030's and given the rapidly expanding supply capacities globally that anything like the current global coal prices will be sustainable.

- **Carbon Taxation, Cap-and Trade and Border Carbon measures**

There currently exists only the most modest global GHG emissions trading system under the terms of the Kyoto Protocol⁶⁵. Nevertheless, individual countries have moved on a national or regional basis to impose measures that would limit emissions within their respective jurisdictions. These national measures pose a challenge for the global coal industry as one of the greatest emitter of GHG and create uncertainty for countries like Botswana which are remote and landlocked potential suppliers of coal. In the absence of an international treaty obligation to limit GHG emissions a patchwork of national policies has emerged over the last decade and there exists the risk that countries that do impose various measures to restrict GHG emissions in their jurisdiction will begin to impose what are known as border carbon measures or import duties on goods imported from countries that either impose no or lower standards for GHG emissions within their jurisdiction. All these measures increase the uncertainty of developing Botswana's coal industry as what has emerged from a global patchwork of GHG policies is a series of often adhoc measures that creates incentives to a shift towards renewables that can be accelerated by any jurisdiction through the use of national measures.

EU policy

EU policy uses by far the most sophisticated and globally important policy instruments to encourage renewable energy and diminish GHG emissions. The EU began the process by attempting to impose a pan-European carbon tax in the 1990's⁶⁶. This was opposed by Greece and Spain because of their levels of industrialization and also by the UK as taxation was seen as a sovereign issue. As a result of the failure the EU eventually adopted an emissions trading system instead of a carbon tax, as the centerpiece of its emissions reduction strategy of reducing GHG gas emissions by 20 percent below 1990 levels by 2020⁶⁷. The ETS is a cap-and-trade system, imposed midstream on large emitters. The emissions trading base is made up of four broad sectors: (1) iron and steel, (2) certain mineral industries (including cement), (3) energy production (including electric power and refining) and (4) pulp and paper. It is limited to combustion facilities with a thermal input of greater than 20 MW. Across the EU, this comprises roughly 12,000 facilities.

Carbon taxes were also imposed but at a national level starting with the Scandinavian states in the 1990's well before the establishment of the European emissions trading scheme. Even though these systems were finally implemented concurrently with the ETS. More recently, other countries have endeavored to introduce a domestic carbon tax. Switzerland successfully introduced a carbon tax in 2008 and Ireland in 2010. France failed in its attempt in 2010. While the Scandinavian states imposed carbon taxes in 1990's they chose not to opt out of the EU ETS and therefore provide a double incentive to local firms to change technology.

⁶⁵ The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC). <http://unfccc.int/resource/docs/convkp/conveng.pdf> The UNFCCC is an international environmental treaty with the goal of achieving the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system..The Protocol was initially adopted on 11 December 1997 in Kyoto, Japan, and entered into force on 16 February 2005. As of 2011, 191 states have signed and ratified the protocol. The only remaining signatory not to have ratified the protocol is the United States.

⁶⁶ Elbeze1 J. & de Perthuis C. (2011) 'Twenty years of carbon taxation in Europe: some lessons learned' Information and Debate Series, No 9, University of Paris, <http://www.chaireconomieduclimat.org/?paged=4&lang=en>

⁶⁷ COM (2008) 30 final (n 1). Available at www.energy.eu/directives/com2008_0030en01.pdf

The EU has also developed a renewable energy policy which has explicitly targeted the choice of technology unlike either carbon taxes or the ETS. The EU Directive on Renewable Energy set an ambitious target such that the EU will reach a 20% share of energy from renewable sources by 2020 and a 10% share of renewable energy specifically in the transport sector⁶⁸. Two separate routes have been used by EU Member states to achieve this objective. The first has been through the use of feed-in tariffs and second through tradable green certificates-based quotas (TGCs). In countries with feed-in tariffs, owners of distribution networks are required to accept renewable electricity fed into the network and pay a fixed, regulated price (or price premium) for that electricity. Denmark adopted this in the 1980s followed by Germany and Spain in the 1990s, and is now the dominant system in the EU⁶⁹. In tradable green certificate-based quota systems (TGCs), renewable electricity is sold in the usual electricity market at market prices, but these sales are complemented by certificate trading in a separate market for green certificates. The certificates are demanded by obligated buyers (e.g. electricity suppliers or consumers) who must buy certificates corresponding to a certain quota of their total electricity sales or consumption. Here, countries such as Belgium (Flanders), Sweden and the UK have been early adopters⁷⁰.

EU policy has been effective in driving not only EU but also global change in GHG emissions and the more rapid application of these technologies. In a globalized world when the world's largest trading entity moves on technology the effects will almost certainly be dispersed globally over time. However, while the EU has not moved in any way to use punitive trade or economic measures such as border carbon adjustments against countries which do not maintain GHG and renewable standards similar to that imposed on its own firms this option remains open. The risk of such measures may also explain why countries have moved to emulate renewable energy policies of the EU and US.

China

In virtually all major economies there has been, over the last decade a series of policies that have provided stimulus to the development of renewable energy in general and solar and wind power in particular⁷¹. Despite its reputation for high dependence on fossil fuels China has lead the way in terms of renewable energy policy development. In 2005, at the same time as the EU introduced its ETS China moved to pass Renewable Energy Law of 2005. The stated objective was to “promote the development and utilization of renewable energy, improve the energy structure, diversify energy supplies, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society.” From a virtual zero base where renewable energy, with the exception of Hydro electricity were not part of the energy mix, China moved to introduce a system of middle and long term targets of renewables, mandated connection to the Chinese grid and made purchase from renewable suppliers obligatory. The government provided a direct subsidy to renewable energy of USD0.029 /kWh, provided low interest loans to developers. The cost of these subsidies to renewable energy, over and above that of electricity generated by coal was simply to be passed on the consumer of electricity in the form of higher prices.

In order to implement the law the government introduced the Medium and Long-Term Development Plan for Renewable Energy (MLTPRE) in 2007. The MLTPRE established national deployment goals by technology to reach renewable energy. The “Guiding Principles” of the MLTPRE state that it focused on hydropower, wind, solar, and biomass energy development and deployment, coordinating renewable

⁶⁸ http://ec.europa.eu/energy/renewables/targets_en.htm downloaded November 22nd 2011.

⁶⁹ See Fouquet, D. and Johansson, T. (2008): European renewable energy policy at crossroads – Focus on electricity support mechanisms, *Energy Policy* 36: 4079-4092. Rowlands, I. H. (2005): Envisaging feed-in tariffs for solar photovoltaic electricity: European lessons for Canada, *Renewable and Sustainable Energy Reviews*, 9 (1): 51-68.

⁷⁰ See Menanteau, P., Finon, D. and Lamy, M.-L. (2003): Prices versus quantities: choosing policies for promoting the development of renewable energy, *Energy Policy*, 31 (8): 799-812. Verhaegen, K., Meeus, L. and Belmans, R. (2009): Towards an international tradable green certificate system – The challenging example of Belgium, *Renewable and Sustainable Energy Reviews* 13 (1): 208-215.

⁷¹ See Solgani K.H et. al (2011) ‘A review of global solar energy policy’ *Renewable and Sustainable Energy Reviews*, Vol.15, No 4,, Pp. 2149-63

energy development with economic, social, and environmental objectives. Overall, the MLTPRE aimed at raising the share of renewable energy to 10% of total primary energy consumption by the end of 2010, and 15% by 2020. By 2020 China expects to be producing 150 gw of wind power, 20gw of solar and 430 gw of hydro electricity⁷². In terms of the results of China's renewable energy policy a recent US government report concludes, (page 5)⁷³:

The wind power sector is illustrative of China's accomplishments, as installed wind power capacity has gone from 0.567 gw in 2003 to 12.2 gw in 2008, and China surpassed the United States in 2010 with over 41 gw of installed wind power capacity..... Plans already exist to grow China's wind power capacity to 100 gw by 2020. A similar goal exists for the solar photovoltaic power sector which China intends to increase generating capacity from 0.14 gw as of 2009 to over 1.8 gw by 2020.

China's electricity demand is expected to double over the coming decade⁷⁴ and renewable energy (with the exception Hydro-electricity), having began from an almost zero base are growing at an exponential rate. China will remain a major and growing market for coal and it will continue to constitute a very large part of its energy mix in the coming years. However, China has also announced its intention to introduce a carbon trading scheme in six regions by 2013 and nationwide by 2015. China has an ambitious strategy to cut its "carbon emissions intensity", that is, carbon emissions per unit of GDP by 40-45% by 2020⁷⁵. The introduction of carbon trading in China will accelerate the pace of application of renewable energy in the country and given the very ambitious target announced this will effect the long term demand for coal. However, China has introduced development subsidies that have helped establish the renewable energy sector first and then moved to introduce a system of trading. It has thereby created the industry which will facilitate a response to higher non-renewable energy prices. Significantly China, from an almost zero base at the beginning of the century, is now the world's largest exporter of solar energy systems.

India

The coal market of possibly greatest interest to the Botswana coal mining sector will be the rapidly growing and physically proximate Indian market. The government of India has also moved first to introduce a revenue generating carbon tax and by 2014 to introduce an emission trading systems. In 2010 the government moved rapidly to impose a carbon tax on coal of 50 rupees per tonne (USD1.05)⁷⁶. Compared to the recent Australian carbon tax of USD 23 per tonne these taxes are not considered high. India sets emission levels for 563 of the country's biggest polluters, such as power and, steel mills and cement plants, allowing businesses who use more energy to buy carbon certificates from those who use less. Emissions trading is expected to start in 2014 in India as per the Bloomberg report on July 01, 2010⁷⁷.

⁷² China also plans to produce 10 million tonnes of bioethanol and 2 million tonnes of biodiesel by 2030. A large portion of this will be produced overseas, a significant part in Africa.

⁷³ Richard J. Campbell, (2011) China and the United States - A Comparison of Green Energy Programs and Policies Congressional Research Service, 7-5700, R41748, http://assets.opencrs.com/rpts/R41748_20110330.pdf

⁷⁴ Chain Daily (Xinhua) 2010-12-21 'The China Electricity Council projected that the country's consumption will almost double from 2010 level to 8.2 trillion kWh by 2020. In a report on the electricity industry's development in the 12th Five- year Program (2011-2015) the CEC said electricity consumption this year will reach 4.17 trillion kWh and increase to 6.27 trillion kWh by 2015,. China's installed power generating capacity will grow from this year's 950 million kilowatts to 1.885 billion kilowatts by 2020, the CEC report said, adding that by 2020 about 36.3 percent of installed capacity will come from non-fossil fuels' http://www.chinadaily.com.cn/china/2010-12/21/content_11736078.htm Downloaded 25th November 2011

⁷⁵ The Guardian 10 July 2011, 'Carbon tax and emissions trading: how countries compare' <http://www.guardian.co.uk/environment/2011/jul/10/carbon-tax-emissions-trading-international> downloaded 25th November 2011.

⁷⁶ *ibid*

⁷⁷ It should however be pointed out that in NDP the official estimate was that diamond exports would start to decline dramatically by 2018 when Cut 8 at Jwaneng came to an end. Cut 9 is now expected. Mining companies do not normally invest in proving up reserves for more than 20 years ahead.

India expects to raise \$535 million from a levy on coal producers starting today, the first step by Asia's third-largest energy consumer to charge companies for fossil fuel pollution.

India has also set a target of reducing GHG emissions in 2020 by 25% below the 2005 levels.

Botswana can assume that national and regional policy measures to limit GHG emissions such as carbon taxes, ETS and renewable energy subsidies and supports will only become more common in future. Once industries are established, with time and economies of scale they will no longer require government support. **Given the expected decrease in renewable energy prices Botswana's coal deposits must be seen as having a limited commercial life.** If Botswana is to take advantage of the opportunity of coal government needs to move expeditiously.

Conclusions: Coal and Economic Diversification - A matter of Timing

It is broadly expected that by 2027 the open cut deposits of diamonds in Botswana at the Jwaneng diamond mine will come to an end and, barring further significant discoveries, revenue for the Botswana government will have to rely on other sectors. Diamond exports from less profitable underground deposits are likely to continue for at least another decade but revenues will decline sharply. If coal production has an economic life of 30-40 years, depending upon the change in relative prices of electricity generated from coal as opposed to renewable sources, then it will play a significant role in the country's economic diversification.

Certainly the new deposits of coal along with the discoveries of copper/nickel will form a basis for diversification in the mining sector. However, the benefit of coal as an export product for the diversification of the Botswana economy will rest ultimately on timing. The window of opportunity for coal development is narrowing with the changes in relative energy prices occurring globally implying that over a period of 30 years the relative price will move against electricity generated from coal. Therefore the commercial opportunities for exporting coal are certainly time bound. No public feasibility study exists for a railway to the coast from Botswana however breakeven can only be expected to occur over a period of 15-20 years. Furthermore, the long period of construction of between three to five years that can be reasonable expected means that coal exports starts to run up against an unknown coal demand in the 2020's and 2030's. The greatest immediate risk is that potential financiers of a BOT railway may see the gestation period as too long given the changing technological, GHG policy and price environment in the coming years. It is therefore imperative that decisions regarding rail infrastructure be made as expeditiously as possible as Botswana may miss a market opportunity altogether.

There are not inconsiderable uncertainties about the future of coal prices given the pace of technological change occurring in the use of renewables. This is compounded by policy pressures in developed and developing countries. The outcomes of the Durban COP17 indicates that the major GHG emitters including India and China are ready to develop more stringent emission restrictions which may or may not fall short of legally binding obligations. Irrespective of the legality of an international instrument both countries are currently developing domestic GHG policies which indicate a convergence of global policy on the matter. Add to this the expanding capacity in global coal production currently occurring in remote and relatively high cost locations such as Columbia and Russia and the rapidly

changing economics of renewable energy a potential structural over-supply situation in the 2020-2030's cannot be discounted.

At present there is great private sector interest in the development and export of Botswana's coal. Botswana, due to its inherently high cost structure and membership in SACU has few diversification options and the development of thermal coal exports is certainly one of the few private sector lead diversification options that requires limited government intervention beyond that of the development of infrastructure. However, the longer the decisions on key ancillary infrastructure are delayed the more this private sector interest will wane. This includes not only the development of a railway but the need for the development of a national water grid that provides sustainable water from the Zambezi to those more remote regions, such as the Ghanzi-Maun corridor where significant base metal extraction is also expected in the coming years.

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Appendix

Mining Water Demand and Water Pricing in Botswana

Assuming that a railway is built there are expected to be between 6-13 new coal, diamond, copper and nickel mines opening within the next decade in Botswana. These will all require considerable quantities of water⁷⁸. In Botswana the general obligation of mine licensees in the past has been to procure their own water⁷⁹. Such a policy may have been appropriate when there were only a few mines widely dispersed around the country with relatively little obvious conflict between mining and other end users but with the expected growth of mining, ground water abstraction is highly unlikely to be sustainable in the mining sector. In light of the fact that some of the areas where these new mines are located are very arid and existing boreholes and artesian supply is needed for agriculture, the current water policy with regards to mining and energy projects needs to be reconsidered. This is particularly so given that the experience at Orapa and at Botash has shown that underground water usage in mining has proven to be unsustainable⁸⁰. Indeed government of Botswana publications indicate quite clearly that the current rate of abstraction from nine major well fields is greater than the estimated sustainable level in the case of all with the exception of Ramotswa⁸¹. Some like the well fields in Dukwi which service, in part, the Botash mine are experiencing unsustainable rates of water abstraction.

The country has a policy of moving away from unsustainable groundwater use. To that end Botswana intends to abstract some 495Mm³/a from the Zambezi⁸². If this project proceeds without serious objection and delay from the other countries with riparian rights to the Zambezi river basin and even with the substantial water usage for irrigation in the Pandamatenga area, then there should be sufficient sustainable supplies for a coal export industry in Botswana. However, in the absence of such infrastructural investment in the coming years a coal export industry will have to rely upon water from existing capacities. In 2010 the last year for which such data was available the Water Utilities Corporation used some 58 Mm³/a to supply all domestic needs in towns⁸³. The most recent estimates of water usage in Botswana suggest a total water usage of 170Mm³/a in 2003⁸⁴.

⁷⁸ It has been estimated that Botswana has total annual renewable freshwater potential supply of 14.7 billion m³/year, Botswana is ranked 11th among the 14 southern African states when absolute water availability is considered. However, its small population of 1.7 million at the time meant that ranked it fifth when per capita water availability, estimated at 8904 m³, is used as a criterion. These figures include brackish and non-potable ground water resources. see Matiza-Chiuta T.; Johnson, P. and Hirji, R. 2002. Water resources and the economy. In Hirji, R.; Johnson, P.; Maro, P. and Matiza-Chiuta, T. (Eds), *Defining and mainstreaming environmental sustainability in water resources management in southern Africa*, pp. 21-51. Maseru: Southern African Development Council.

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⁸⁰ Government of Botswana 'The Makgadikgadi Framework Management Plan, Volume 1, Main report 2010 page 51 states that:
Since 1984 the Orapa mine has become wholly dependent on groundwater... Continued mining of this groundwater at current rates may not only reduce long term water supply to the mine but also effect supply to other uses (e.g domestic water in Lethakane and surrounding villages and the numerous cattle posts in and around the mine well field .
... estimated water abstraction rates at Dukwi well field (supplies Botash) are estimated at around 6,600m³ per day.....Current abstraction exceeds recharge, estimated to be 600m³/day.

⁸¹ Central Statistics Office' Botswana water Statistics, October 2009, csobots@gov.bw Statistics Printed by and Obtainable from, Department of Printing and Publishing Services Private Bag 0081, Gaborone

⁸² Republic of Botswana, Ministry of Minerals, Energy and Water Resources Department of Water Affairs, Feasibility Design Study on the Utilization of the Water Resources of the Chobe/Zambezi River Tender No. PR 10/3/1/09 Draft Prefeasibility/Feasibility Design Study Report, August 2010 http://www.water.gov.bw/images/Draft%20Prefeasibility_Feasibility%20Report.pdf downloaded 25th November 2011

⁸³ Annual Report Water Utilities Corporation-2009/2010

⁸⁴ Policy Brief on Botswana's water management , 2006 Department of Environmental Affairs, Ministry of Environment Wildlife and Tourism

Water Consumption by Mining Companies - 2008 & 2010 M³

Company	Water Consumption	Comment
Tati Nickel	2,373,560	Tati Nickel purchased its water from WUC
Tati-recycled	389,715	Tati recycles some of its water
BCL	6,386,904	Water used by BCL is either from WUC or recycled.
Botash	21,856,000	Botash abstracts its brine, brackish and potable water from well fields. 90% of total abstraction is brine
Morupule	663,998	This figure is for bore abstraction for 2010 and does not include purchases from WUC
Jwaneng	8,397,407	“
Orapa/Letlhakane	8,437,664	“

Source: Botswana Water Statistics, Central Statistics Office, 2009 and data for 2010 provided by MMEWR

Water supplied to mining companies is based on either direct supplies from WUC or abstraction through bore holes. The current government policy is that Water Attenuation Rights from bore holes incurs no marginal cost on the rights owner except the private cost of abstraction⁸⁵. This system penalizes companies such as the Morupule Colliery which, while still using bore water, have invested heavily in more sustainable methods of procuring water by building a pipeline to the North-South Carrier and therefore assuring a greater supply of sustainable surface water. Moreover, the current pricing arrangement, whereby ground water is provided at a zero price does nothing to encourage water recycling, the development of new dry sorting technologies in coal or the development of appropriate water demand management by mining companies. Given that urban Batswana pay an average cost⁸⁶ in 2009/10 of 9.57 pula/m³, such a pricing arrangement where large mining companies pay no royalty for ground water could be considered as inequitable⁸⁷. The WUC price structure outlines below combined with the absence of royalty or price for water abstraction will create a natural incentive for mining companies to use ground water rather purchase higher cost water from WUC. In case of BCL where the cost of WUC supplied water is below the marginal direct cost of pumping ground water the choice of WUC water makes commercial sense.

⁸⁵ Companies pay an initial Pula 60 with the application for their rights. There is no further charge.

⁸⁶ The price paid by small consumers i.e. less than 5 cum/month was Pula 1.9/m³ in 2009/10. It should be noted that the WUC is highly subsidized and that a significant portion of this price comes from government subventions.

⁸⁷ Water from the Water Utilities Corporation is sold at prices to some mining companies below that paid by low income urban consumers ie Pula 1.9 for the first 5cum/month. Economies of scale would in part explain these differentials.

Consumer	Price (Pula/M3)	Water Type
Tati Nickel	1.59	Raw water
Mupane Gold	2.00	Raw water
Botash	1.50	Raw water
BCL	0.90	Raw water
Moropule	5.70	Raw water
Debswana	0-10M3@1.85; 11-15m3@3.70; 16-25m3@4.85; above 25 m3@5.55	Potable Water
Individual and Corporate Consumers	0-5m3@1.90; 5-20m3@4.75;20-40@9.8; above 40@12.15	Potable water

Source: Water Utilities Corporation, Annual Report 2010. The reason offered for the very low price paid by BCL on water comes from the fact that the infrastructure for that water was provided by BCL

Economists would argue that water of identical quality should be priced in a neutral manner i.e. not differentiating between surface and underground sources and even brackish or saline water can have a long term opportunity cost given the declining cost of desalination and what will ultimately be the growing need for water in coming generations. Without an appropriate price for ground water there is also no significant financial incentive for coal mining companies to employ existing dry technologies⁸⁸ and appropriate water management techniques that will minimize ground water abstraction. Given the absolute necessity of ground water in most rural areas **there are obvious social benefits in a dual pricing model, differentiating between the pricing of large and small volume water abstraction.**

One is obliged to ask whether the WUC prices charged to mining companies are appropriate. Rand Water, in South Africa in 2010/11 was charging mining companies ZAR 6.8/m³ for water for mining purposes⁸⁹. This is far larger than the highest price than the highest price (P5.7/m³) being charged to mining companies in Botswana (see above). WUC needs to reconsider water prices charged to mining companies to bring them in line with comparable prices abroad.

South Africa is a much more water abundant country than Botswana and based on scarcity value the SA price should constitute the minimum floor for an appropriate price to Botswana. Based on 2010 the average cost of water from WUC was P9.57/m³. In Botswana the cost of production of water is much higher than in South Africa because of small and physically dispersed population and because of the need for many more water retention dams because of the aridity of the country and its topology.

Using the WUC P9.57/m³ average cost as a base the price of ground water to mining companies should be based on opportunity cost i.e. the equivalent of what could be available from WUC in the absence of access to ground water. However, ground water needs to be pumped (at a cost of P2/m³) and in some cases desalinated where it is brackish or brine⁹⁰. The cost of best practice desalination of brackish water is (USD0.40/m³ ie P3/m³). Thus starting with a brackish water abstraction prices of P4.6/m³ to P7.6 m³ for fresh ground water would result in price **neutrality between water from WUC and artesian sources.**

⁸⁸ L. von Ketelhodt and C. Bergmann (2010) 'Dual energy X-ray transmission sorting of coal' *The Journal of The Southern African Institute of Mining and Metallurgy* Vol, 110, pp 371-378

⁸⁹ <http://www.randwater.co.za/SalesAndCustomerServices/Tariffs/Rand%20Water%20Tariff%202010-11.pdf>

⁹⁰ Fresh water is normally defined to have a salt content of less than 0.05%. Brackish water has a salt content of 0.05-3%, saline water 3-5% and brine is at 5%.

However, price neutrality may be admirable the important question arises as to whether mining companies in Botswana have the ability to pay such a price. The Debswana group of mines including Morupule abstracted some 18.4Mm³ of ground water in 2010. At a price of Pula 7.7/m³ for fresh water from bore holes this would generate revenues to government of Pula 141 million. The three companies have adequate profits and are currently paying prices from WUC of up to P5.7/m³. The one company that would confront serious problems in paying a real price for abstracted ground water is Botash which abstracts brine as its raw material. This is not a highly profitable enterprise and government may wish to consider excluding its brine abstraction from such water pricing.

For new coal mining companies which are yet to establish, given the very low ROM costs there seems little doubt that almost all companies could afford to pay for bore water. Assuming all water abstracted is brackish and therefore charged prices of P4.7/m³, coal mining alone would bring in P195 million in water revenue for the government. It is doubtful that such a price would act as major disincentive to what are highly profitable mines, given current coal prices.