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COAL MINING AND THE ENVIRONMENT

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Abstract

The environmental impacts of coal mining in South Africa are reviewed. The primary impacts arise from mining, particularly underground mining, largely because South African coal mines are relatively shallow. Coal washing gives rises to large waste dumps, which may ignite spontaneously and cause air pollution. Water pollution arises from some abandoned mines and waste dumps. However, the biggest impact arises from the combustion of coal domestically. Inefficient appliances give rise to copious smoke, and dense smog over towns in winter. The tonnage consumed this way amounts to only 0.3% of the tonnage mined, but the air pollution it causes comprises as much as 30% of the total particulate load in the South African air. The legislative controls over coal mining and pollution are outlined. It is concluded that while the coal mining applies good environmental standards to its operations, it may need to pay more attention to the mine-to-ash aspects of coal use.

Introduction

Given the size of South Africa's coal mining industry, it is no surprise that its environmental impacts are considerable. It would be unrealistic to expect any industry moving nearly 300 million tons of product each year not to have some impact. When that product is dirty and flammable, then the risks presented by handling such a mountain are all the greater.

In this paper I hope to show:

- What the risks comprise
- How the mining industry has been working to mitigate those risks; and
- How the legislative framework for environmental management guides the mitigations.

As with all products, once they leave the producers hands, it is often difficult for the producer to keep control environmentally, and some of the greatest impacts occur far from the point of production. Nevertheless, I hope to show that the industry is addressing the mine-to-ash-heap life of its product reasonably aggressively, and working with its customers to ensure that the environment of coal is not as black as it is often painted.

Impacts from mining

Mining in South Africa takes place both on surface and underground. Approximately equal tonnages come from each. Surface mining is either by strip mining, usually using draglines to remove the overburden and later replace it in the mined-out area, or by opencasting, with the overburden being removed and dumped elsewhere. Underground mining is generally by pillar support methods, with the coal being extracted between the pillars, which then remain to support the roof. A small quantity of coal is mined by longwalling, when all the coal in the seam is extracted and the roof is permitted to collapse behind the mined-out area.

Of all these methods, strip mining is probably the most environmentally friendly. This may come as a surprise to some, because the method has a poor reputation. This is largely because

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the method had the reputation for ruining the landscape by leaving heaps of almost sterile spoil. While the mine is in operation, this is a valid criticism, but once mining is complete, rehabilitation can start. Rehabilitation requires planning, and one of the first things that happens when the mine is opened is to remove the topsoil and store it separately. Once rehabilitation is possible, the spoil is replaced in the excavation, the surface graded and the topsoil spread and seeded. In this way it is possible to restore the surface such that the prior existence of a mine becomes almost unnoticeable. There is some risk that the subsurface hydrology may have been irremediably disturbed, and create the threat of the release of acidified water, but because most of the coal (from which the acidity is generated) has been extracted, and because the coal measures are generally below the regional water table, the threat is limited and can usually be mitigated by sealing off the points where release of any acidified water might occur.

Strip mining is also environmentally friendly and more sustainable than underground mining because it extracts virtually all of the extractable coal. There is a possibility that some thin, uneconomic or low-grade seams above the primary seams may not be mined, but become mixed with the spoil and thus contribute to the threat of acid generation either from the spoil heaps or from the fill in the mined-out area, and there are few ways of avoiding this problem when it occurs. Fortunately it is rare, and in many cases nearly uneconomic upper seams are made economic, and recovered, by the very practice of strip mining.

Opencast mining is practised when the geology makes strip mining inappropriate. An example is the huge Grootegeluk coal mine in the Limpopo Province. The primary coal measures are some 80m thick, and lie below a few metres of overburden. The coal is distributed in thin seams interspersed with bands of shale and stone – the deposit in vertical section looks like a huge barcode. There is then about 10m of solid rock, and secondary coal measures are found. They comprise solid bands of coal several metres thick.

The impacts of opencast mining are considerable. Huge overburden dumps, often contaminated with waste coal, spread across the horizon. The coal in such dumps may combust spontaneously and emit sulphurous fumes and smoke. The mine will invariably create a huge pit, which may eventually fill with water and provide recreational facilities.

Underground mining takes place when the coal seams are too deep to be able to afford to remove the overburden. Typically this occurs when the coal seam is >40m deep. The average depth of underground mining in South Africa is only 80m, which is shallow compared to many coalmines around the world. The deposit is mined by extracting square "rooms" about 10m wide and leaving behind pillars to hold up the roof. Because the seams are generally not consistent horizontally, it is difficult to mine "longwalls" where all the coal is mined and the roof allowed to collapse behind the mined-out area. In South Africa only about 5% of the underground coal is mined by longwalls.

The environmental impacts of underground mining are considerable. One of them is methane. Methane is a "greenhouse gas" that is 21 times more potent in its greenhouse effect than carbon dioxide, and methane is growing in the atmosphere at a faster rate that carbon dioxide (although off a lower base). All coal contains some methane. The deeper the mine, the higher is the amount of methane in the coal. As mining proceeds, the methane is released into the mine air and eventually discharged into the atmosphere. South Africa currently emits nearly 7 million tons per annum of carbon-dioxide equivalent from the underground coalmines.

A further impact is the collapse of the roof between the pillars in the long term. This can cause terminal damage to surface structures, and render the surface almost unusable. Even worse is the risk that the coal remaining in the pillars may heat and eventually ignite. As the burning pillar collapses, the roof falls in, admitting air and allowing the combustion products to escape. The exact extent of this phenomenon is under investigation, but preliminary

estimates suggest as much carbon dioxide is emitted from this source annually as from the generation of electricity in South Africa. Land over burning, worked-out mines is totally unusable.

The pillars also represent a large surface area, and sulphur compounds in the coal are slowly oxidized by exposure to air. As they oxidize, they generate acid, and the acid can leach out and so give rise to "acid mine drainage." Fortunately many South African mines are below the local groundwater level, and once the mines are abandoned and fill up with water, air cannot reach the coal and acid production stops. Some polluted water remains, but the impact is comparatively small. In contrast, many mines in the Kwa-Zulu region lie above the local water table. Oxidation of the sulphur in the coal continues for many years and there is a heavy load of acid mine drainage. Fortunately, most of the Kwa-Zulu mines are relatively small, with outputs rarely exceeding 1 million tons per annum,

Surface impacts

Much coal is processed after leaving the mine to meet market quality demands. The wastes from processing can be used for power generation, and South Africa has a proud record of learning to burn almost incombustible wastes containing as much as 45% ash. Nevertheless, about 80 million tons of coal wastes are dumped annually. There is a risk of ignition, so the dumps are compacted to reduce the ingress of air, and covered with layers of soil to further reduce the fire risk. Once ignited, the dumps are very difficult to put out, and some dumps left by previous generations continue to smoulder.

One of the impacts from burning dumps is the release of sulphur oxides. The sulphur compounds are concentrated in the wastes, and so contribute far more than the equivalent amount of clean coal. For many years the atmosphere of the Highveld was highly polluted, but the gradual extinguishing of the burning dumps has seen a marked improvement in atmospheric conditions.

Another risk from the surface dumps is the slow oxidation of the sulphur compounds and the leaching of the resultant acid by rainwater percolating through the dump. Covering the dump reduces the rate of percolation, but most dumps give rise to a small amount of acid, which is collected and neutralized. The resultant impact is salination of the stream by dissolved sulphates, and, in a water-poor country like South Africa, this is to be avoided as far as possible. Fortunately the degree of salination of our waters has not yet reached excessive levels, nor does it seem likely to do so in the foreseeable future.

Impacts from coal use

The largest market for coal in South Africa is the electrical generating industry. This releases some 170 million tons of carbon dioxide annually, about 0.7 million tons of nitrogen oxides and about 1.5 million tons of sulphur oxides. Most stations have sufficiently tall stacks that discharge occurs above the mixing level, and the prevailing winds carry the pollutants out over the Indian Ocean where they disperse.

Because the average coal burned contains a little over 1% sulphur, which is low by many standards, the sulphur pollution cannot be regarded as excessive. It is technically possible to recover the sulphur, but it is not economically viable in South Africa. Much of our development is driven by cheap power – the average sent-out cost is R0.065/kWh, which makes it among the cheapest power in the World. It is estimated that sulphur recovery would add at least R0.15 to this cost, and involve millions in capital that could far better be expended on creating jobs and infrastructure.

The carbon dioxide emissions are the inevitable result of power generation. Most of the South African power stations are large (~4000MW) and efficient (over 34% thermal efficiency), which minimizes their releases per unit of energy generated. It is a point of some concern that transmission losses average over 7%, but this is the effect of having a large country with a relatively dispersed population.

Ash from power generation presents few problems. The finer fraction is almost entirely used as a cement additive. The coarser fraction has little leachable, so presents minimal threat to the aquasphere. Being coarse, dispersion to atmosphere is nigh impossible, so air pollution effects are absent. Probably the greatest concern is the uranium content of 300-600ppm. Initially this of little concern, as most of the radioactivity comprises some volatile or gaseous components such as radon, which are driven off during the combustion process. As the ash is stored, however, the radioactivity returns by natural processes. It reaches levels similar to many granites, and because the ash dump is more mobile than solid rock, there is a greater chance of dispersion.

One "use" of South African coal is the generation of export earnings. The Richards Bay Coal Terminal is the largest single-purpose terminal in the world, able to ship over 80 million tons of product annually. It is served by a dedicated rail line from Witbank. The environmental impacts of this are minimal.

About 1 million tons of coal finds its way into South African homes. The homes are particularly those on the high plateau of Gauteng, the Free State and Mpumalanga known as the "Highveld", where, because of the altitude, winter nighttime temperatures below 0^{o}C are common. The coal is burned primarily for space heating, although many homes have stoves which permit cooking, the heating of water and the combustion of refuse in addition to heating. Homes without stoves use open braziers.

The environmental impacts of this practice are considerable. Air pollution from smoke and sulphur oxides is widespread, while indoor concentrations of carbon monoxide of over 1200ppm for 8h are regularly observed. For comparison, the general standard internationally is a maximum of 50ppm for 1h. Extrapolating from European experience suggests these conditions will reduce life expectancy by about 15 years.

Clearly this is an environmental disaster of no mean magnitude. The Department of Minerals and Energy has had a programme of nearly 10 years duration to develop a low-smoke alternative, and a solution of an affordable fuel seems at hand. The problem is exacerbated by the fact that many of the homes involved are constructed of sheet iron. The resultant poor insulation means that there must inevitably be large quantities of energy consumed in an attempt to stay warm. Many homes already spend over half their household income on fuel in winter months, so any alternative fuel cannot cost any more than coal does.

The legislative environment

In South Africa the mineral industry is mainly regulated by two Acts. The Minerals Act, 1991 (Act 50 of 1991), regulates, *inter alia*, the prospecting for and optimal exploitation of minerals, and the rehabilitation of the surface of land during and after prospecting and mining operations. The Mine Health and Safety Act, 1996 (Act 29 of 1996) provides for protection of the health and safety of employees and other persons at mines. These Acts are administered by the Department of Minerals and Energy (DME).

In terms of the Constitution of the Republic of South Africa, 1996 (Act 108 of 1996) all laws and matters relating to mineral and energy are administered under the control of the Minister of Minerals and Energy in the National Government. The Government does not seek to participate in the exploitation of South Africa's minerals and views its involvement in the mineral industry as being of a complementary nature only. The main legislation is the

Minerals, 1991. This Act seeks to ensure that the State fulfils its responsibility towards the community in respect of the mineral industry, by regulating:

- The prospecting and mining for minerals;
- The orderly utilisation of the mineral resource; and
- The rehabilitation of the surface of land during and after prospecting and mining operations.

It also seeks to ensure security of tenure for mineral investors.

The Minerals Act, 1991, was made applicable throughout the national territory from 1 May 1995. Three issues are involved, namely

- A prospecting contract or a mineral lease agreement concluded with the holder of the mineral rights;
- A prospecting permit or mining authorisation issued by the DME (which is a "license" to conduct prospecting or mining operations); and
- An Environmental Management Programme (EMP) which must also be approved by DME.

The prospecting contract or mineral lease agreement, and the prospecting permit or mining authorisation, are regarded as "rights" and the fact that they cannot be changed unilaterally is important to the mining industry as risk capital is involved.

A slight complication arises from the fact that mineral rights were transferred to the so-called TBVC (Transkei, Bophutatswana, Venda and Ciskei) states and self-governing territories such as Kwa-Zulu during the *apartheid* years. With the re-incorporation of these territories into the Republic in 1993, various arrangements were necessary to preserve rights established when these territories had been self-governing. For instance, in Bophutatswana the Minister of Land Affairs became the trustee of tribal lands, and it has been arranged that that any applications to prospect or mine will first be submitted to the DME for comment before Land Affairs will consider it. In Lebowa, the mining rights were controlled by the Lebowa Minerals Trust, and administration of this Trust has been transferred to the Minister of Minerals and Energy, who must consult with the administration of the Limpopo Province before any decision on mining rights is reached. In the former KwaZulu the relevant land and mineral rights were transferred to the Ingonyama trust. The Zulu king is the trustee of the Ingonyama trust and the Provincial Government of KwaZulu/Natal, through the KwaZulu Finance Corporation, administers the mineral rights held by the trust.

The EMP spells out the obligation of the prospector or exploiter with respect to the environment, and it cannot be regarded as a right. Furthermore, section 41of the Minerals Act, 1991, recognises the fact that the management of the environment may change during prospecting or mining operations. It therefore requires ongoing assessment to limit any damage to the environment that may be caused by prospecting or mining operations. DME may, in terms of section 39(2)(b) of the Minerals Act, 1991, allow amendment of an EMP.

DME has a regional office with a Director: Mineral Development in every province of the Republic. These offices are located in Cape Town, Port Elizabeth, Kimberley, Dundee, Welkom, Klerksdorp, Johannesburg, Pietersburg and Witbank. An applicant for a prospecting or mining authorisation must obtain the permission of the mineral rights holder (if it is privately held) before the application is lodged with the Director: Mineral Development. The negotiations with the holder of the mineral rights, as well as with the landowner regarding

surface usage, are concluded in terms of common law. However, should there be a conflict of interests, the DME may be approached to act as mediator.

The Minerals Act, 1991, requires the holder of a prospecting permit or mining authorisation to submit an environmental management programme (EMP) for the land concerned in the prospecting or mining operations, to the Director: Mineral Development for his approval. Operations cannot start without obtaining approval. Before the Director: Mineral Development can approve an EMP he must consult with every department charged with administering any law affecting the environment. Approval of an EMP may take a considerable period, and the legislation allows the granting of a temporary permit to proceed with prospecting or mining operations.

The EMP is based on the principles of Integrated Environmental Management laid down in the National Environmental Management Act, (Act No. 107 of 1998) (NEMA). Of course, the Mining Act preceded NEMA, and it is a matter of some pride in the mining community of South Africa that they took the lead in implementing sound management practices before other industries were legally required to do so. Since 1992, more than 7000 environmental management programmes have been compiled and submitted to the Department.

Auditing and monitoring of the EMP form an integral part of the principles. Because each mine has an individual character, each mine requires its own monitoring and auditing programme. Performance assessment and monitoring focus on:

- Compliance with the EMP
- The appropriateness and effectiveness of the EMP

Integration of the requirements of the Minerals Act with other environmental systems such as ISO 14000 is encouraged, and mines applying ISO 14000 have greatly reduced reporting responsibilities in terms of the Act.

Section 38 of the Minerals Act, 1991, requires the holder of the prospecting permit or mining authorization to rehabilitate the surface of land concerned:

- In accordance with the EMP approved in terms of section 39;
- As an integral part of the prospecting or mining operations;
- Simultaneously with those operations, unless the Director: Mineral Development agrees otherwise; and
- To the satisfaction of the Director: Mineral Development.

Thus since the coming into force of the Minerals Act, 1991 every mine in South Africa has had to have rehabilitation of the disturbed land in mind from the outset of operations. Figure 1 illustrates the way in which integration is accomplished.

To overcome some problems of enforcement, particularly in small or marginal mines, the Director: Mineral Development may require the establishment of a trust fund adequate to ensure decommissioning and aftercare. Most mines incorporate such a trust fund into the EMP as a matter of course. The fund is finally closed when the mine has satisfied the Director: Mineral Development that it has complied with all the requirements of the EMP and been granted a certificate of closure in terms of Section 12 of the Minerals Act, 1991.

The question of the rehabilitation of mines abandoned or closed before the coming into operation of the Minerals Act, 1991 continues to pose problems, and Government is actively seeking the industry's assistance in finding solutions.

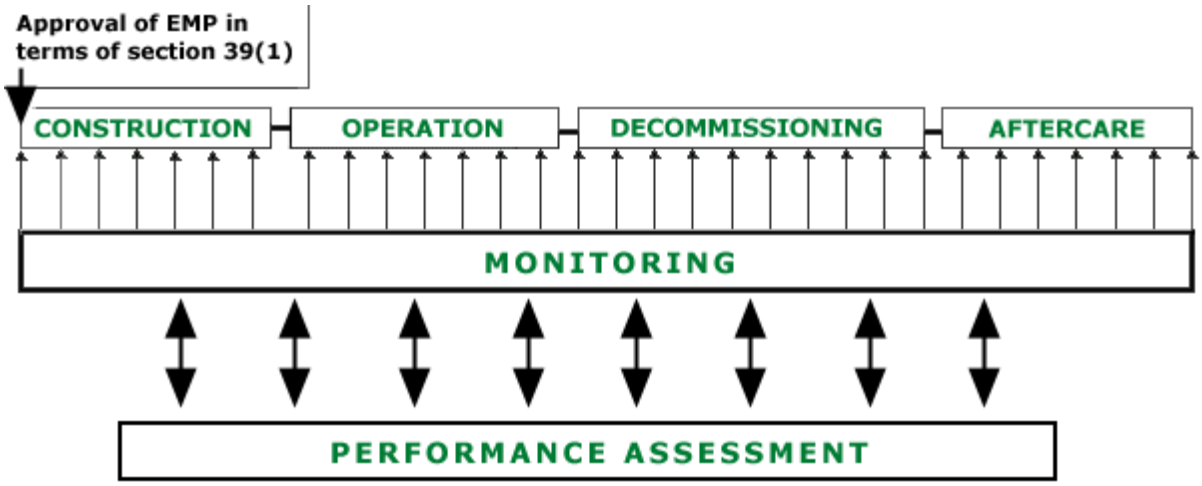

Figure 1 Integration of EMP into all aspects of mining operations

Findings

Given the fact that the coal mining industry in South Africa mines well over 300 million tons of ground annually, the impacts of its operations are relatively benign. Certainly, when measured against the industry's contribution to the national economy, the residual impacts from mining as such are modest.

Similar remarks may be made about most of the impacts from coal's use. Certainly the availability of cheap coal makes the South African economy a major emitter of greenhouse gases per capita, but the benefits from having affordable energy far outweigh any possible impacts of our contribution to global warming. This is clearly seen when electrical energy becomes unaffordable and perhaps as many as 5 million citizens face the prospect of having their life expectancy severely affected by the inappropriate use of coal. This is a clear and demonstrable link – in contrast, we cannot find one person in the nation whose life is demonstrably adversely impacted by global warming.

The legislative environment has contributed to ensuring a generally good environmental performance from the South African coal mining industry. The industry has inherited some horrors from the past, of which the burning of abandoned underground mines is probably the worst. I say "probably" because it is only recently that we have come to grips with the problem, and started to quantify its magnitude.

The EMP system is contributing strongly to the long-term sustainability of the industry. After ten year's experience of the Minerals Act, 1991, the effects, originally thought by many in the industry to be unduly onerous, have in fact turned out to be benign if not positively beneficial.

Some changes have come into the system, of which the most important has probably been conformance between the Minerals Act, 1991 and NEMA. The issue of an EMP requires the usual processes of consultation with the public and scoping, and in one celebrated case (SAVE vs Department of Minerals & Energy, AD 2000) the Applicants argued successfully that in reaching the decision to issue a permit to mine, the Director: Mining Development had given inadequate opportunity to the affected communities to make their concerns known. The regulatory framework has been modified accordingly to make the consultative process conform to the citizens' constitutional rights.