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The application of Economic Modelling to enhance decision-making at Lonmin Platinum

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Lonmin Platinum

The recent load shedding requirements prescribed by Eskom to the South African mining industry have forced management to focus on electrical energy consumption as an important factor affecting mine production and profitability. Management decision-making around the optimization of electrical energy consumption is now critical to future mine planning and company valuations.

Lonmin has developed an Economic Model (EM) that can assist management with scenario planning and decision-making. The model allows users to run multiple scenarios and analyse the impact on Net Present Value (NPV) and short-term profitability. The EM takes cognisance of technical constraints (e.g. tonnage, electrical energy, water, compressed air, etc.) and can therefore be used to assist with the electrical energy consumption problem.

This paper describes the process followed in the development of the EM and the learning points from this exercise.

Introduction

The use of scenario-planning to enhance management decision-making in an ever changing global environment is a practice widely used by many mining companies today. The development and use of an Economic Model (EM) that allows analysis of multiple discreet scenarios is a critical prerequisite to the scenario-planning process.

This paper discusses the development of the EM at Lonmin and its application to management decision-making under an electrical energy constrained environment.

Lonmin Economic Model

Application

Typical applications for Economic Modelling in the mining business are shown in Figure 1.

The foundation of an economic model is its mechanism to translate complex technical input data, company business rules and assumptions as well as macro- and micro-economic assumptions into credible financial outputs.

The technical inputs provide the following uses:

- To analyse and benchmark the integrity of the technical plan versus historical data.
- To formulate the metal content schedule and resultant revenue line
- To calculate working costs through the choice of predetermined technical drivers
- To ensure correct allocation of working costs and capital.

Typical outputs of scenario analyses include life cycle cost volume curves per planning entity and Net Present Value (NPV) calculations used for project and shaft

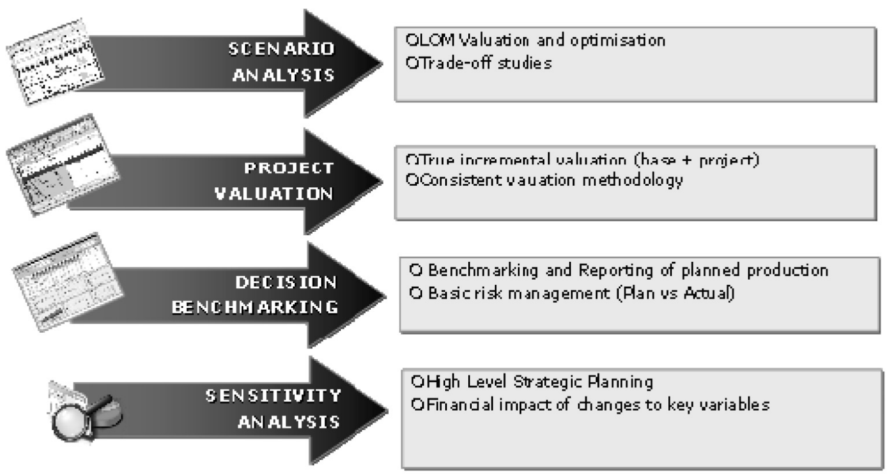

Figure 1. Typical applications of Economic Modelling

decision-making. A number of NPV optimization techniques can be employed with the use of the EM, such as conceptual hill of value calculations (Hall, 2003), capital rationing and tail management (Lane *et al*., 2006).

Incremental project valuations can be made by calculating the NPV of the planned tax entity, both with and without the project. This technique provides more accurate project valuations as a result of cost dilution and related efficiencies when projects are considered. An EM is ideal for stress-testing multiple scenarios for concept and pre-feasibility studies, to ensure that the 'best case' scenario is taken forward to feasibility level.

Decision benchmarking is a useful management reporting tool to compare shafts or planning entities in a three-dimensional environment as depicted in Figure 2.

Sensitivity analysis and high level strategic planning can be done by means of 'what if' scenarios (e.g. breakeven commodity price per planning entity).

Design criteria requirements

A major design requirement is that the EM be developed initially in Microsoft Excel™ (Ballington *et al*., 2004) or similar spreadsheet-based software. The reason for this is that there are normally multiple changes in the logic and layout of the EM due to the constant evolution of user requirements. These changes in requirements are typically uncovered throughout the development phase. When the scope of development of sophisticated software is changed during the development phase, it can be time-consuming and costly. There is also a need for the role players to clearly understand the underlying logic on an ongoing basis as the modelling and development progresses.

The key message for the design criteria is to keep it simple. Bearing this in mind, the following criteria need to be clearly articulated before commencement of the development phase:

- Map out the interaction of the EM within the existing planning process (e.g. interaction of scenario-planning with the life of mine planning, etc.).
- Identify model data requirements as well as ownership of these inputs to the model.
- Determine the level of granularity of calculations and outputs (bearing in mind that the model size is proportional to the level of granularity of calculation, compounded by the inherent limitations of modelling complex relationships in a spreadsheet environment like Microsoft Excel™).

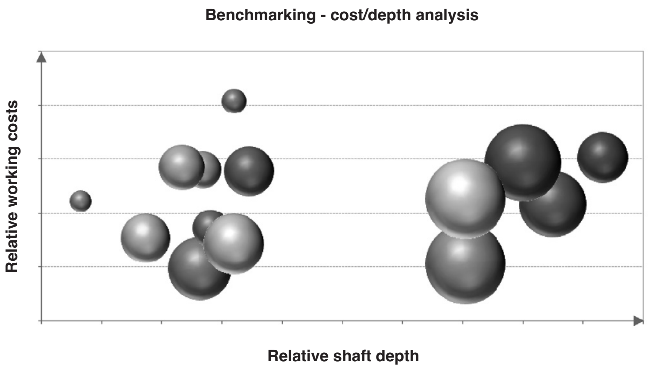

Figure 2. Cost benchmarking

- Determine minimum standard reporting required and what objective functions, questions and decision-making criteria will be asked from the EM by the executive and management.

Development and implementation learning points

During the development and implementation phase, there is a need to ensure that all the stakeholders are constantly kept informed through regular feedback sessions (Lane *et al*., 2006). An internal champion is a prerequisite for project success, preferably with technical and financial background and knowledge. The project team can consist of a variety of skills, but the champion needs to understand the complete process flow of technical data from the rock face to the cost drivers through to the NPV calculation. Other key learning points during the development and implementation phase are:

- Integrity of technical input data
- Alignment of costing categories with the financial costing systems
- Transparency of logic (make use of a user's manual which clearly translates the underlying logic)
- Pilot a prototype model for a specific shaft or planning entity before rolling out the implementation to other entities and the rest of the mine
- Keep it simple and do not try to take on too much detail in the prototype model. Too much detail and complexity upfront leads to a 'black box' syndrome. The logic of inputs to outputs needs to evolve in unison with the understanding of the key role players
- Make use of an external consultant for the prototype phase build up capacity internally once the model is working and being rolled out to the rest of the mine.

Structure for continuous improvement

The need to structure the EM for continuous improvement is centred on speed or ease of use and quality of the outputs. The ability of a mining organisation to expedite scenario analysis work is constrained by the ability of the planning personnel and mine planning systems to expedite design and scheduling work. This, combined with integrated data transfer of planning and costing data into the EM, provides a platform for continuous improvement. Sufficient time needs to be allocated to do quality checks of the input as well as output data at the relevant data transfer points. Logic can also be incorporated into the EM to check the integrity of the data inputs and outputs and to flag anomalies on an analytical review basis.

The way forward for the EM is to focus on improving management decision-making. With that thought in mind, management decision-making can be enabled by bringing the EM to the boardroom so that scenarios can be run and decisions made in a structured manner based on the predetermined decision-making criteria.

The application of the Lonmin EM to management decision-making around the recent electrical energy restrictions

In light of the recent electrical energy restrictions prescribed to the South African mining industry, electrical energy consumption has become a key factor in short-term and long-term planning, affecting both profitability and production. The application of scenario-planning combined with the Lonmin EM was used to identify options and improve management decision-making around this problem.

Background

In order to gain an understanding for the main consumers of electrical energy at its Marikana operations, Lonmin contracted EMS Pty Ltd (Electrical Energy Management Systems) to assist with analysis work in 2006. The following five groups were defined at the Marikana operations for analysis of contribution to electrical energy consumption:

- Concentrators (or plants)
- Compressed air
- Shafts
- Hostels
- Office and workshops.

The contribution of the predefined groups to the electrical energy consumed by the mine was calculated and shown in Figure 3. The results indicate that the concentrators are the largest consumer of energy on the mine, followed by compressed air and shafts. However, if the actual allocation of compressed air electrical energy consumption is split between concentrators and shafts, the shafts group is actually the largest consumer of electrical energy, as approximately 85% of compressed air usage is consumed by the mining activities at the shafts (Du Plessis, 2008).

The main mining activities that consume electrical energy are drilling and cleaning. The graph in Figure 4 depicts a typical main incline feeder's demand in kW.

The relationship between electrical energy consumption and tons hoisted is verified in Figure 5 by extrapolating a fitted line plot of monthly electrical energy consumption (kWh) versus tons hoisted for the Marikana operations.

Using this technique, the shaft electrical energy can be predicted through a regression analysis formula using planned tons hoisted. The total predicted electrical energy consumption per shaft can be formulated by adding the regression analysis figure to the split allocation of the compressor electrical energy consumption between the shaft and the concentrator.

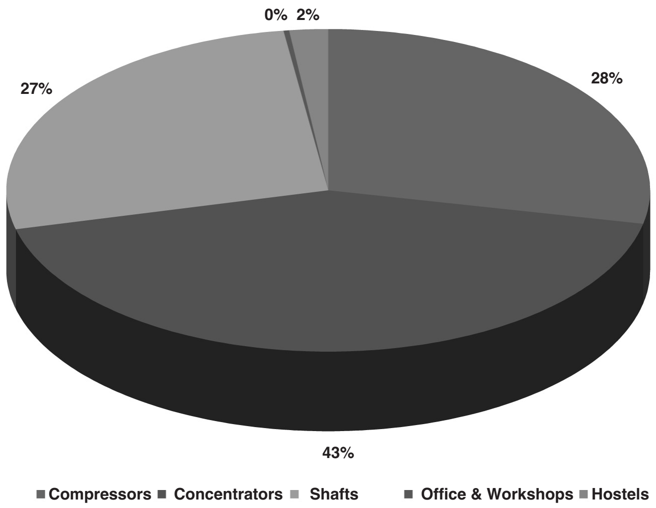

Figure 3. Contribution to total electrical energy consumption of the mine

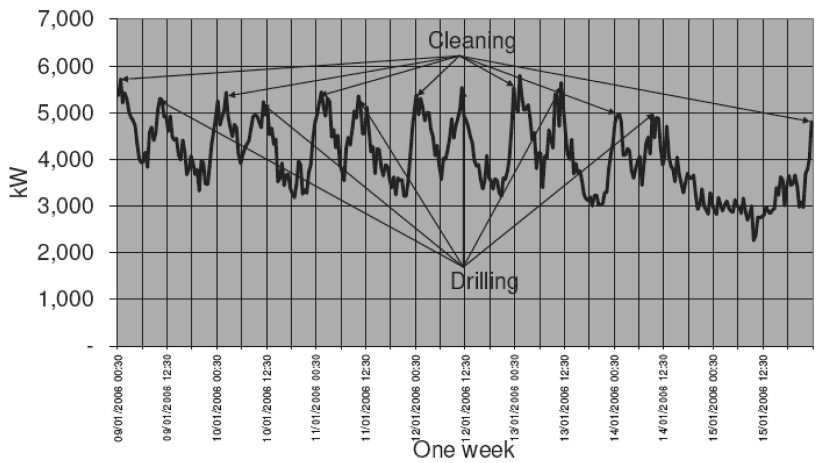

Figure 4. A typical main incline feeder showing mining activities

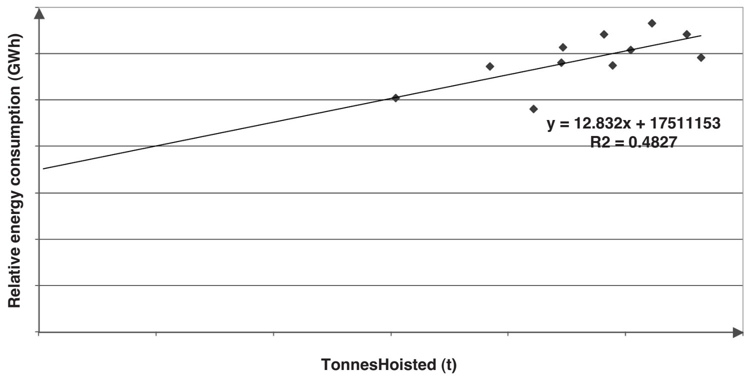

Figure 5. A fitted line plot of monthly electrical energy consumption vs. tons hoisted for the Marikana operations

Objectives

An exercise was done comparing the electrical energy consumption of six shafts (two mechanized and four conventional shafts) from the Marikana complex which are named Shafts A to Shaft F in Table I.

The total predicted electrical energy consumption was calculated for each of the shafts using the life of shaft tonnages in the EM. The following objectives were set:

- Understand the relationship of tonnage or volume and shaft depth to electrical energy consumption.
- Compare the electrical energy consumption of mechanized mining to conventional mining.
- Rank the shafts according to long-term value and electrical energy consumption (NPV per kWh).
- Rank the shafts according to short-term value and electrical energy consumption (net profit per kWh).
- Improve management decision-making for potential future constraints on electrical energy consumption.

Analysis

Using output charts from the EM, Figure 6 shows that the electrical energy consumption per shaft increases with depth and tonnage. Tonnage is the major factor affecting electrical energy consumption for the shafts considered. Figure 7 compares electrical energy consumption per ton (kWh/t) against depth. Using shafts B and F as an example, the effect of additional electrical energy consumption from mining at depth is offset by increased production tonnage.

The reduction of electrical energy consumption observed in the mechanized shafts is mainly due to the impact of reduced reliance on compressed air. In a report done by the Centre of Mechanised Mining Systems (University of Witwatersrand) on the implications of trackless mechanized platinum mining for electrical energy consumption, it was stated that significant savings in electrical energy can be achieved by converting stoping operations to trackless mechanized mining (Du Plessis, 2008). The main factor in achieving the electrical energy saving is the ability to replace compressed air for drilling. The report also stated that Lonmin's current electrical energy consumption for compressed air generation is a half to a third compared to other older, deeper mines in the industry where the reticulation efficiency of compressed air is lower (Du Plessis, 2008). In an environment where the cost of electricity could double over the next few years, the benefits of the reduction of electrical energy consumption by using mechanized mining methods could relate to a

Table I
Description of shafts used for exercise and depths below collar

	Description	Depth BC (m)
Shaft A	Mechanised	419
Shaft B	Mechanised	804
Shaft C	Conventional	363
Shaft D	Conventional	333
Shaft E	Conventional	419
Shaft F	Conventional	804

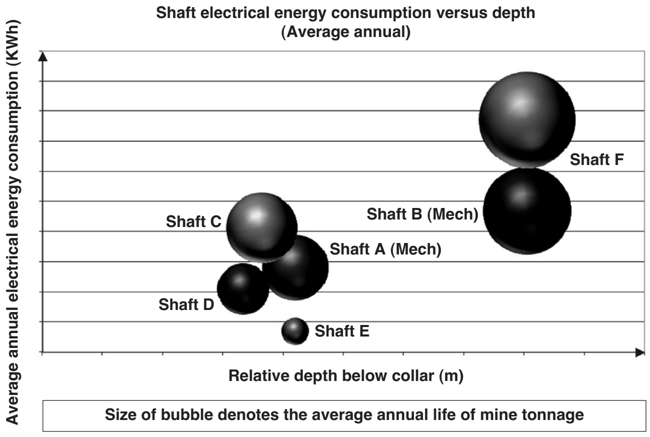

Figure 6. Shaft electrical energy consumption (kWh) vs. depth

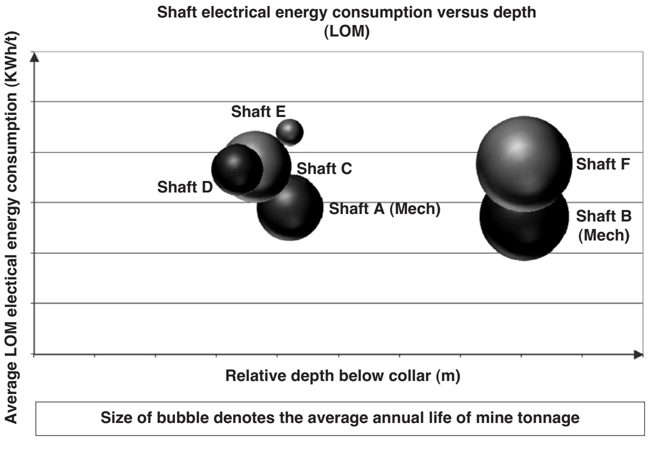

Figure 7. Shaft electrical energy consumption (kWh/t) vs. depth

significant saving in working cost. Obviously the benefits of electrical energy efficiency need to be offset against the mechanized consumables (diesel, tyres).

In an electrical energy constrained environment there needs to be a focus on maximizing long-term value whilst ensuring short-term profitability for Lonmin. Figure 8 shows the ranking of the shafts in an unconstrained electrical energy environment according to long-term value (NPV at company hurdle rate) and depth of the shafts.

Figure 9 shows that the ranking of the shafts according to NPV/ kWh can change decision-making. For example, in an unconstrained electrical energy environment, shafts F and C rank high on NPV, whereas in an electrical energy constrained environment (NPV/kWh), the same shafts are not so attractive.

The projected short-term profitability was calculated using the EM. Figures 10 and 11 show the mechanised shafts to be not as profitable or energy-efficient. This is due to the fact that the mechanized shafts are in a production ramp up phase. The electrical energy inefficiency surrounding shaft F continues in the short-term electrical energy constrained environment.

For this exercise, the combined long-term and short-term decision-making environment can be combined on a single chart of NPV/ kWh and projected profit/ kWh as shown in Figure 12. The decision being that in an electrical energy constrained environment, shaft F, despite being a highly profitable shaft, might need to be scaled down or put on care and maintenance to retain shareholder value.

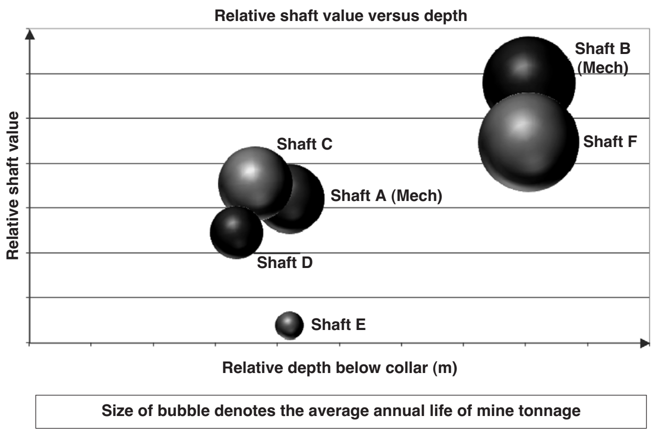

Figure 8. Shaft NPV vs. depth

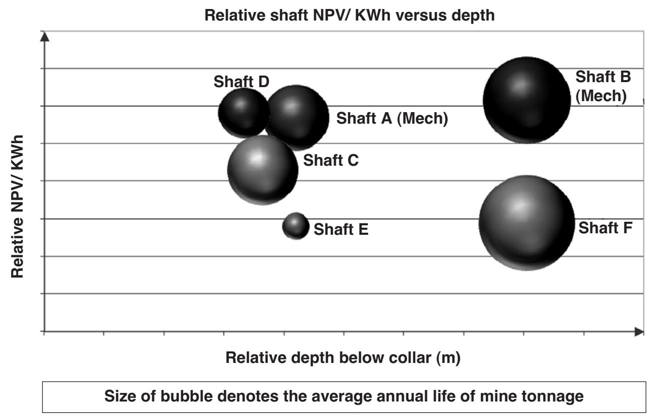

Figure 9. Shaft NPV/ kWh vs. depth

Learning points from this exercise

- Electrical energy consumption increases with depth and production tonnage.
- Highly profitable shafts are not necessarily the most efficient on the basis of electrical energy consumption.
- There is potential to conserve electrical energy through the application of mechanized mining.
- Short-term and long-term decision making around electrical energy consumption can be contradictory.

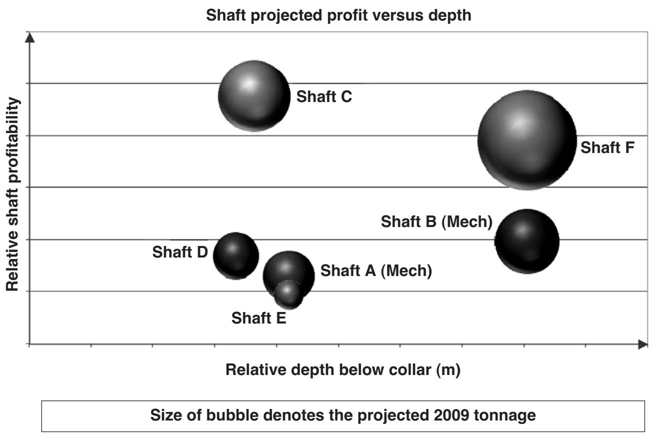

Figure 10. Shaft profit vs. depth

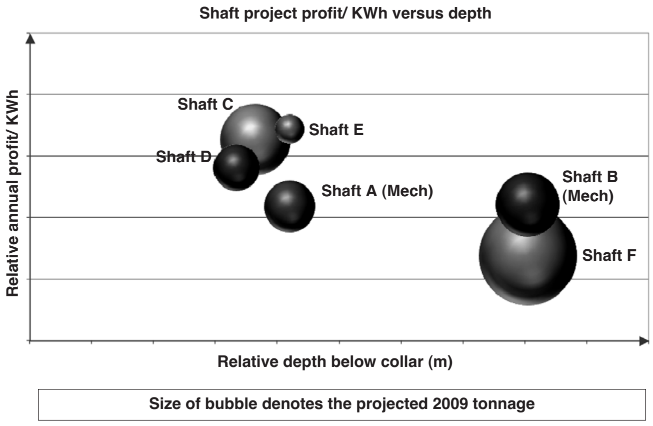

Figure 11. Shaft profit/ kWh vs. depth

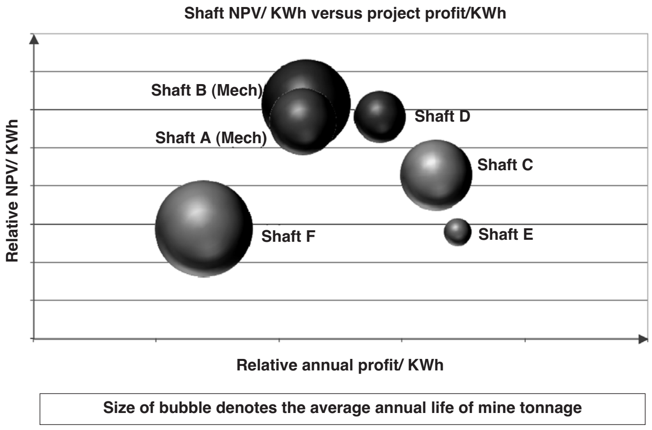

Figure 12. Shaft NPV/ KWh vs. projected profit/kWh

Conclusions

An Economic Model is a useful management decision-making tool that combines technical and financial information. The integrity of the Economic Model is based on stakeholder interaction during the development phase and the quality of the input data, assumptions and business rules in the model. The exercise done using the EM to compare the electrical energy consumption from a variety of shafts at Lonmin revealed interesting learning points that can effect future management decision-making.

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In 1992, Mark obtained his Bachelor of Science Degree in Mechanical Engineering from the University of Witwatersrand. He was appointed as a Section Engineer at Impala Platinum Limited after obtaining his Government Certificate of Competency: Mines & Works in 1996.
Mark was the Operations Engineer of a large platinum Concentrator for 4 years and was also appointed as the Operations Manager of the plant for a year. He joined Lonmin Platinum in 2001 as a Project Engineer and was instrumental in the design and construction of Lonmin's new generation EPC & K4 Concentrators. In 2003, Mark was appointed as the Section Engineer of one of Lonmin's larger vertical shafts, where he was responsible for the leading the maintenance and logistics of the shaft. At the end of 2005 he moved into the role of Systems Engineer for the Marikana mining division of Lonmin, where he led the Maintenance implementation team for all the shafts.
Mark was then appointed as the Consulting Engineer for Lonmin at the end of 2006. His accountabilities were to oversee the strategic integration of the recently implemented Maintenance system, to provide technical advice on various projects within Lonmin and to assist with the development of the Long Term Business plan.
Mark was recently appointed as the Senior Manager: Engineering in the Mining division in June 2008.