A CONCEPTUAL FRAMEWORK FOR STRATEGIC LONG TERM PLANNING OF PLATINUM MINING OPERATIONS IN THE SOUTH AFRICAN CONTEXT

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A thesis submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy.

Johannesburg, 2011

DECLARATION

I declare that this thesis is my own unaided work. It is being submitted to the Degree of Doctor of Philosophy to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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31st day of March 2011

ABSTRACT

The challenge facing a South African mining company, with multiple mining rights to platinum mineral resources, is to create sustainable value whilst operating within mandated strategic bounds, identified constraints, and variable market and economic conditions.

This can be achieved by allowing the fixed physical nature of the mineral asset to drive definition of the optimal (lowest capital and operating cost) technical solution to mining and processing activities, and developing and resourcing a strategically aligned portfolio of production entities that creates flexibility to near and longer term business environment shifts, i.e. a production mix that allows variation of output (metals, operating cost, capital intensity) to respond to short term market variation, within a long term context.

The practical achievement of this outcome is enabled by the application of the strategic long term planning framework. The framework logic, methodology and components are described and the application demonstrated through a case study (Anglo Platinum Limited).

Prior to definition and description of the strategic long term planning conceptual framework, the context of the South African platinum industry is described through consideration of the characteristics of the mineral resource, the platinum value chain, the PGM market, and the global and local business environment.

The core elements of the framework, and the relationship between them, are expanded: scenario planning, business value optimisation, long term planning parameters, long term planning procedures, capital investment prioritisation, project value tracking, the relationship of the long term plan to the business plan, contingency planning and execution plans for supporting capability (projects, metallurgical, infrastructure and people).

The implementation of the framework at Anglo Platinum Limited is considered over the period 2004 to 2007 with a description of the business response, facilitated by the framework and established capability, following the 2008 global financial crisis.

It is concluded that the strategic long term planning framework is a logic construct that enables delivery of an optimised, strategically aligned, business plan from the mineral asset portfolio using a set of tools and techniques with a common language, standards, systems and processes that align decisions and actions on a cyclical basis.

DEDICATION

This work is dedicated to the two people who have significantly influenced this work, but in very different ways.

To Wendy,

without whose unwavering support and gentle urging over the years, I would not have completed this documentation of three decades of applied learning in the mining industry.

Thank you.

and

To David Diering,

who through his inspirational work at Anglogold, in early 2000,

established mineral resource management

as a discipline within the South African mining industry.

His groundbreaking effort provided the context for adoption of the

strategic long term planning conceptual framework

by Anglo Platinum Limited in 2004.

ACKNOWLEDGEMENTS

The development and application of this strategic long term planning conceptual framework would not have been possible without the unequivocal support of the Executive Committee of Anglo Platinum Limited.

Formal acknowledgment is therefore given to the Executive Committee of Anglo Platinum Limited, for support and the necessary mandate to develop and implement this strategic long term planning approach across Anglo Platinum operations, primarily during the period 2004 to 2008, and then through subsequent evolutions during 2009 and 2010.

Further acknowledgement goes to the members of the Strategic Long Term Planning Department at Anglo Platinum who adopted and executed the conceptual framework over the period 2004 to 2008, and to their successors, in the Mineral Resource Management Department, during 2009 and 2010.

Thanks to their tireless efforts, the philosophy of strategic long term planning has been established within Anglo Platinum; the people, the processes and the systems are in place - with the efficacy of the results being evident during the trying 2008 global financial crisis and subsequent recovery period over 2009 and 2010.

Further acknowledgement goes to my supervisor, Professor R.C.A. Minnitt (JCI Chair of Mineral Resources and Reserves, University of the Witwatersrand), for his invaluable academic guidance and review of progress.

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oz – ounces troy
koz – thousand ounces troy
Moz – million ounces troy
t – tonne (metric ton)

g/t – 4E grams per tonne (4E referring to the four elements of Pt, Pd, Rh and Au)
ppm – parts per million

Ir – Iridium
Os – Osmium
Pd – Palladium
Pt – Platinum
Rh – Rhodium
Ru – Ruthenium

Au – Gold
Cu – Copper
Ni – Nickel

NOMENCLATURE

BEE – black economic empowerment

BRIC – referring to the countries of Brazil, Russia, India and China

Bushveld Complex – is the world's largest known mafic-ultramafic intrusion on earth which forms a platinum mineral resource

CAGR – compound annual growth rate

Capex – capital expenditure can be further broadly categorised as: expansion (increasing production output), replacement (maintaining current production levels without an increase in output) or “stay in business” (maintenance of existing infrastructure capacity)

DCF – discounted cash flow – a financial evaluation technique based on discounting of anticipated future cash flows. Discounted cash flow analysis provides a means of relating the magnitude of all expected future cash flows to the magnitude of the initial cash investment required to purchase the asset and develop it for commercial purposes

DMS – dense media separation – the process whereby minerals are separated by virtue of relative density

EP – economic profit is the net operating profit after tax of the business (or project, or operation), less a charge for the capital required to earn that return

ETF – exchange traded fund

Geozone – an area, which can be identified and defined, having the same distinctive geological features within a larger rockmass

Global assumptions – long term economic and planning parameters encompassing assumptions on exchange rates, metal prices, inflation, capital and operating cost escalators, on and off-mine costs, based on the prevailing world view (scenario), updated and released quarterly

HSF – Hyperion Strategic Finance – a customised financial modelling application from Oracle Corporation. HSF is used to perform valuations and assess capital investment decisions, and to run, consolidate and produce the long term plan (LTP)

IC – investment centre – the minimum area of analysis of a mining right area. The size of an investment centre is defined by the area of analysis associated with an application for development capital funding

IRR – internal rate of return – the rate of return which the expected future cash flows, in a discounted cash flow analysis, will yield on the original cash investment

JV – joint venture

LHD – load haul dump – a type of rock loading and hauling (rock handling) equipment

LoM – life of mine – the anticipated life of mining operations across a mining right under a given set of long term planning parameters and strategic intent

LTP – long term plan

MDR – multi discipline review – planning review encompassing all disciplines

Merensky reef – a platiniferous ore body in the Bushveld Complex
MES – mine extraction strategy – an unconstrained view of how the mineral asset could be exploited (scale, timing, capital cost)

Mineral asset – any right to explore or mine (or both) that has been granted, or entity holding such property or the securities of such an entity including but not limited to all corporeal and incorporeal property, mineral rights, mining titles, mining leases, intellectual property, personal property (including plant equipment and infrastructure), mining and exploration tenure and titles or any other right held or acquired in connection with the finding and removing of minerals located in, on or near the earth's crust

Mineral resource – is a concentration or occurrence of material of economic interest in or on the earth's crust in such form, quality and quantity that there are reasonable and realistic prospects for eventual economic extraction. The location, quantity, grade, continuity and other geological characteristics of a mineral resource are known, or estimated from specific geological evidence, sampling and knowledge interpreted from an appropriately constrained and portrayed geological model. Mineral resources are subdivided, and must be so reported, in order of increasing confidence in respect of geoscientific evidence, into inferred, indicated or measured categories

Mineral reserve – is the economically mineable material derived from a measured or indicated mineral resource or both. It includes diluting and contaminating materials and allows for losses that are expected to occur when the material is mined. Appropriate assessments to a minimum of a pre-feasibility study for a project and a life of mine plan for an operation must have been completed, including consideration of, and modification by, realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors (the modifying factors). Such modifying factors must be disclosed

MRP – mining right plan – a physical depletion plan informed by the mine extraction strategy
MSZ – main sulphide zone – the platiniferous target zone of the Great Dyke
NIB (eng) – a category of investment centres not included in the business plan because, despite having been subject to extensive study work through to pre-feasibility level, they are uneconomic for current long term planning parameters
NIB (nw) – a category of investment centres not included in the business plan as they have not had any study work done on them or where exploitation is planned well in the future (>30years)
NPV – net present value – a discounted cash flow analysis technique

OEMs – original equipment manufacturers

Opex – operating expenditure, a generic term for operating cost which is not capital in nature

PGMs – platinum group metals; six elemental metals of the platinum group nearly always found in association with each other. Also referred to as PGE (platinum group elements). These metals are platinum, palladium, rhodium, ruthenium, iridium and osmium. Gold, silver, nickel, copper and cobalt are usually associated with PGMs

Platreef – a platiniferous ore body in the Bushveld Complex

PVT – project value tracking – a methodology for tracking changes in project value over time

SDR – single discipline review – planning review by technical discipline

SIB – stay in business capital – ongoing capital investment required to sustain existing operations and infrastructure. SIB capital is applicable for all capital equipment replacement, business improvement, risk mitigation, ore reserve development and shared infrastructure initiatives after the initial project execution

SLTP – strategic long term plan - the anticipated life of mining operations across a mining right under a given set of long term planning parameters and strategic intent

UG2 reef – a platiniferous ore body in the Bushveld Complex

VBM – value based management – a business philosophy based on value maximisation

1 INTRODUCTION

1.1 Background

For a mining company to create sustainable value from mineral assets, it is necessary to:

- Optimise the mineral asset portfolio to align with strategic and business objectives;
- Create and operate long term assets within an anticipated long term business environment; and
- Create and retain flexibility in the short term tactical response allowing effective response to long term shifts in the business environment.

On this basis it is necessary to:

- Allow the fixed physical nature of the mineral asset(s) to drive definition of the optimal (lowest capital cost, lowest operating cost, highest efficiency, maximised cash flow) technical solution to mining and concentrating activities;
- Define and apply different business environment perspectives, world views or scenarios, to determine possible economic viability under the different perspectives, i.e. define the value proposition under different scenarios – what are the options?
- Develop and resource a portfolio of production entities from the mineral asset portfolio that creates flexibility to near and longer term business environment shifts, i.e. a production mix that allows variation of output (metals, operating cost, capital intensity) to respond to market demand and pricing.

These activities require a structured, integrated approach across all elements of the business value chain from exploration through to product sales, which allows cyclical (typically annual) reassessment and adjustment. Integral to this is a common language, standards, systems and processes to align decisions and actions across the organisation and over time.

Typically, however, organisational structures and operating philosophies create discipline specific groupings ("silos") across the organisation which work against alignment of purpose and integrated outcomes in the long term planning and exploitation of mineral assets.

The solution lies in systematic application of a series of tools and techniques, within a conceptual framework or philosophy, that aligns decisions and actions across the company and defines the concept of *strategic long term planning* - the definition of which is the intent of this work.

1.2 Research problem

The strategic and tactical mining context, which is central to the definition of the research problem, is described as follows by Smith and Ballington (2005, p.294).

"Until recently, the mine planning function has generally been viewed as an engineering function, primarily concerned with the design of access and stoping excavations and the sequence of orebody extraction. Traditionally these planning elements have been considered in two broad groupings; one primarily concerned with the accuracy of estimates (conceptual, pre-feasibility, feasibility studies), the other with time frames (short, medium and long term plans). In reality the elements of these two groups should be applied across two categories of planning over the life cycle of mining operations – *strategic mine planning* and *tactical mine planning.*

Strategic mine planning deals with those components and decisions that largely impact the value of the business over the long term. Central to this is the development of a business model and plan to maximise value from exploitation of the entire mineral resource available to the organisation. This is achieved through consideration and optimisation of the key elements of the value chain: exploration strategy, extraction method, mining sequence, cut-off grade/pay limit, scale of operations, metallurgical processing route, social and labour plans, environmental and sustainable development philosophy, and marketing/sales strategy. The efficacy of the selected strategy and business model, initially defined at the beginning of any business cycle, should be periodically reviewed as internal and external aspects of the business environment are continuously changing. In operating mines, the scope of strategic mine planning is related to the continuous revision of medium and long term business plans (replacement and expansion projects) to ensure that short term operations are consistent with long term strategic objectives. The strategic mine plan is thus necessary to provide consistent direction but also to provide a base against which to assess new exploitation options and projects.

Tactical mine planning encompasses the routine planning activities required to sustain existing operations and implement new projects. This implies continuous re-working of short term plans, preparation of budgets, production scheduling, and process optimisation to meet changes in the external environment. Every tactical activity needs to be assessed such that it is not detrimental to the long term strategic objectives of the business.

In essence strategic mine planning is concerned with decisions that determine the value of the business as a whole whilst tactical mine planning is concerned with the tasks required to achieve that value. The two processes are not mutually exclusive but rather interdependent and should therefore not be separated at any time. However, the respective emphases need to be understood and acknowledged."

Of key consideration to mineral resource companies is the need to optimise value from a finite, non-renewable asset, in a specific legislative context whilst operating in a market environment defined by variable metal prices and exchange rates. The challenge is thus to develop a portfolio of operations, current and future, to ensure optimal resource exploitation and create the flexibility to respond to variable market conditions whilst operating within mandated strategic and legislative bounds.

Strategic mine planning is commonly cited as the solution to the problem however the understanding of exactly what strategic mine planning is and how it is executed is variable and contradictory. Common usage of the terminology belies the fact that the underlying activities tend to be short to medium term planning optimisation rather than strategic planning of the individual mining right or full company mining right portfolio.

Strategic planning in the manufacturing, trade and service industries tends to be primarily directed towards the definition of a tactical response to a company's strategic vision, mission and values. This approach may be augmented or supplemented by approaches encompassing issue-based alignment or scenario based logic. Conceptual frameworks for strategic planning in these industries are well established and widely applied. However owing to the fundamental difference in the asset base between these industries and the mineral resource industry, these frameworks do not readily transfer to the mineral resource industry.

What is thus required is a conceptual framework for the strategic long term planning of mineral resource companies that acknowledges the nature of the depleting mineral asset base, the importance of a defined but flexible project pipeline, variability in market conditions and the requirements of the South African mineral rights legislative environment.

This translates into the fundamental research question of:

How does a company with rights to exploit multiple platinum group metal mineral resources of differing characteristics (e.g. location, grade, metal factor, exploitation method, metallurgical characteristics, physical location, socio-economic setting), select and implement a strategically aligned project portfolio that enables optimal mineral resource exploitation whilst operating within mandated strategic bounds, identified constraints, and variable market and economic conditions?

2 RELEVANCE OF WORK & CONTRIBUTION TO KNOWLEDGE

During early 2004, the author engaged with the then chief executive officer of Anglo Platinum and outlined the strategic long term planning (SLTP) conceptual framework. The logic and intended outcomes were readily accepted and a mandate given to develop and implement the approach across the company.

Subsequently this research work has been ongoing and evolving in a workplace environment driven by practical business needs within an annual planning cycle. Highlights during this progressive development and implementation process have been:

2004

- Inclusion of investment centre logic and categorisation by confidence level into the strategic business plan for 2005.

2005

- Institutionalisation of common long term planning parameters;
- Standardisation of valuation methodology; and
- Standardisation of DCF modelling logic and tools.

2006/07

- Full alignment of projects, process, human resource and infrastructure planning with the long term plan profiles;
- Transition from individual computing to server based valuation modelling; and
- Maturity of SLTP processes, systems and competence levels.

2008

- Managing the impact of the Eskom power supply shortfalls using SLTP outcomes; and
- Use of the SLTP framework to identify and evaluate options in anticipation of the impact of the global financial crisis.

2009/10

- Implementation of contingency plans identified and evaluated in 2008; and
- Definition of recovery trajectories using the SLTP framework.

A number of publications, since 2004, have resulted from this research, and are listed below:

Andersen, D. C., Pearson-Taylor, J. and Smith, G. L. (2005),The strategic long term planning process at Anglo Platinum, *Proceedings of the First International Seminar on Strategic versus Tactical Approaches in Mining*, South African Institute of Mining and Metallurgy, Symposium Series S40, Johannesburg, South Africa, 19-21 September 2005, pp. 9-22.

Ballington, I. R., Smith, G. L., Lane, G. R. and Hudson, J. (2005), The systemic interdependency of closure decisions at shaft level, *Proceedings of the First International Seminar on Strategic versus Tactical Approaches in Mining*, South African Institute of Mining and Metallurgy, Symposium Series S40, Johannesburg, South Africa, 19-21 September 2005, pp.152-164.

Marsh, A. M., Naidoo, D. and Smith, G. L. (2005), The application of Hyperion Strategic Finance in strategic long term planning at Anglo Platinum, *Proceedings of the First International Seminar on Strategic versus Tactical Approaches in Mining*, South African Institute of Mining and Metallurgy, Symposium Series S40, Johannesburg, South Africa, 19-21 September 2005, pp. 277-292.

Pearson-Taylor, J. and Smith, G. L. (2006), The concept of project value tracking and its application in strategic mine planning at Anglo Platinum, *Proceedings of the Second International Seminar on Strategic versus Tactical Approaches in Mining*, Australian Centre for Geomechanics, Perth, Australia, 08-10 March 2006, section 8 pp.1-13.

Smith, G. L., Andersen D. C. and Pearson-Taylor, J. (2009), Strategic long-term planning at Anglo Platinum, *The Journal of The Southern African Institute of Mining and Metallurgy*, vol. 109, no. 3, pp.191-203.

Smith G. L., Andersen D. C., Pearson-Taylor, J. and Marsh A. M.(2006a), Project valuation, capital investment and strategic alignment – tools and techniques at Anglo Platinum, *Proceedings of the Second International Platinum Conference 'Platinum Surges Ahead'*, South African Institute of Mining and Metallurgy, Symposium Series S45, Sun City, South Africa, 08-12 October 2006, pp.35-42.

Smith, G. L., Andersen D. C., Pearson-Taylor, J. and Marsh A. M.(2007), Project valuation, capital investment and strategic alignment – tools and techniques at Anglo

Platinum, *The Journal of The Southern African Institute of Mining and Metallurgy*, vol. 107, no. 1, pp. 67-74.

Smith, G. L. and Ballington, I. R. (2005), The application of discounted cash flow modelling in strategic mine planning, *Proceedings of the First International Seminar on Strategic versus Tactical Approaches in Mining*, South African Institute of Mining and Metallurgy, Symposium Series S40, Johannesburg, South Africa, 19-21 September 2005, pp. 293-304.

Smith, G. L. and Pearson-Taylor, J. (2006), Alignment of capital and strategic intent – challenges and responses at Anglo Platinum, *Proceedings of the Second International Seminar on Strategic versus Tactical Approaches in Mining,* Australian Centre for Geomechanics, Perth, Australia, 08-10 March 2006, section10 pp. 1-6.

Smith, G. L., Pearson-Taylor, J. and Andersen, D. C.(2006b), The evolution of strategic long term planning at Anglo Platinum, *Proceedings of the Second International Platinum Conference 'Platinum Surges Ahead'*, South African Institute of Mining and Metallurgy, Symposium Series S45, Sun City, South Africa, 08-12 October 2006, pp.301-305.

Smith, G. L., Surujhlal, S. N. and Manyuchi, K. T. (2008), Strategic mine planning – communicating uncertainty with scenarios, *Proceedings of the Third International Platinum Conference 'Platinum in Transformation'*, Southern African Institute of Mining and Metallurgy, Symposium Series S45, Sun City, South Africa, 06-09 October 2008, pp. 335-342.

Van Wyk, L. and Smith, G. L. (2008), The concept of value based management and its application in developing value maximising strategies at Anglo Platinum, *Proceedings of the Third International Platinum Conference 'Platinum in Transformation',* Southern African Institute of Mining and Metallurgy, Symposium Series S45, Sun City, South Africa, 06-09 October 2008, pp.315-317.

These descriptive publications, on the SLTP framework and tools / techniques, were presented by the author and members of the SLTP department at various conferences. Subsequently aspects of the SLTP framework logic, terminology and tools have been adopted across many of the Anglo American Group operating units, following transfer of staff, as well as by others in the industry.

The core contribution of this work to knowledge thus lies in:

The development, definition and articulation of a conceptual framework for the strategic long term planning of platinum group metal mining operations in the South African context.

The conceptual framework provides an integrated logic (philosophy), process and methodologies that facilitate long term planning of mineral asset exploitation, within a strategic context. It creates the link between the market requirements, business strategy and tactical planning activities.

The link is created between the business strategy, the market and differing world views (scenarios) across multiple, different mineral assets in the South African platinum mining industry, through the concept of strategic long term planning.

The basis for the development of a portfolio of operations, current and future, that ensures optimal resource exploitation and creates the flexibility to respond to changing economic and market conditions whilst operating within legislative and mandated strategic constraints is defined.

A critical limitation to this work is that the logic developed is primarily suited to a large platinum group metal (PGM) producer with multiple, geographically distributed mining rights with different characteristics and not to a single localised source of production. However the underlying philosophy and approach of this work could be extended to include other metal / mineral production.

3 ORGANISATION OF THIS THESIS

Following a brief literature review and comment on research methodology, this document is structured around the nature and interrelationship of the critical components of the strategic long term planning framework as developed and applied, at Anglo Platinum Limited, during the period 2004 to 2009. The major components of the overall conceptual framework are schematically represented in Figure 3.1 which should be read from the bottom of the diagram, as follows:

- The global and national business environments, in conjunction with the characteristics of the market for platinum group metals create the context in which world views or scenarios are developed. This is part A of the diagram.
- World views or scenarios (part B of the diagram) are constructed and used to develop long term planning parameters called global assumptions or GAs that represent the relevant underlying assumptions for each scenario, e.g. metal prices, exchange rates, escalation, etc. These planning parameters inform the financial analysis and optimisation of the business plan and create the link between the mineral asset portfolio utilisation and the market.
- The annual cyclical business planning process, as represented in part C of the diagram, is then executed using the planning parameters or GAs associated with the preferred or most likely scenario. The composition of the mineral asset portfolio is reviewed relative to the most likely scenario, the current state of execution of projects and company strategic intent. The physical characteristics of the individual mineral assets within the portfolio determine the development of a mine extraction strategy, the mining right plan, the budget and long term plan per asset and collectively for a multi-asset business. Concurrently value is optimised through application of value based management principles during the development of the strategic long term plan – at mineral asset level and company level for a multi-asset organisation.
- The business plan, which is the output of the strategic long term planning process, is then reassessed for a possible shift to the next most likely world view. Real options arising from evolving alternate trajectories are evaluated and a contingency plan is developed, based on planning parameters associated with the alternate scenario. This is the link from part C of the diagram back to part B.

  The business plan then forms the basis upon which the organisation is structured and resourced. Supporting, aligned execution plans are developed for the necessary supporting activities in finance, human resources, projects, engineering and infrastructure, and sustainable development. All of which takes place in an annual planning cycle.

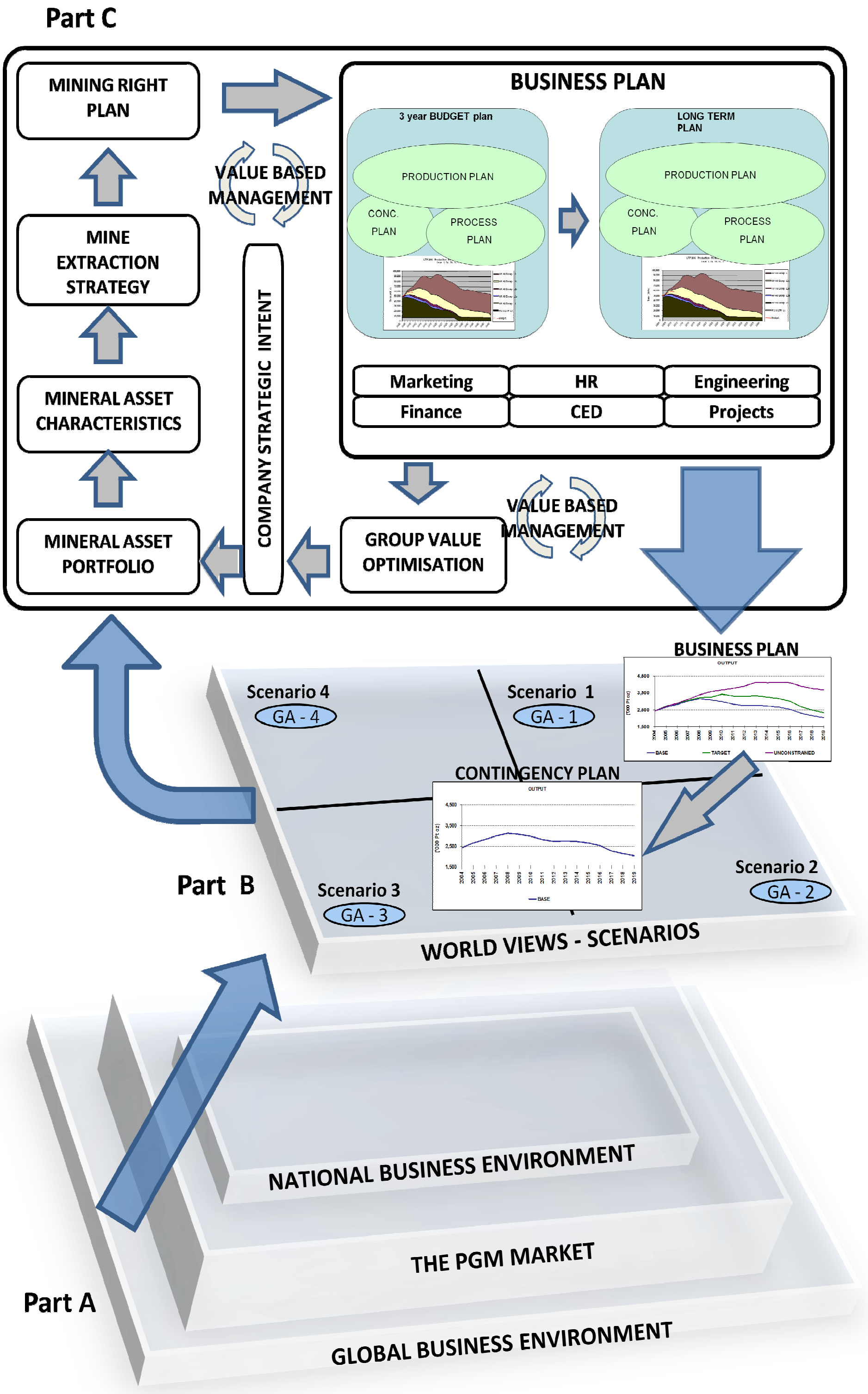


Figure 3.1 Strategic long term planning – schematic of key components of the conceptual framework

Part A of Figure 3.1 is encompassed in Chapters 6, 7, 8, 9 and 10:

- The nature of the PGM mineral asset, which forms the underlying basis of value creation for the PGM industry, is described in Chapter 6 – Characteristics of the PGM Mineral Resource, whilst the critical elements of the PGM value chain are described in Chapter 7;
- The interplay of the nature of the PGM mineral assets and the value chain manifest in the characteristics of the PGM market which is described in Chapter 8; and
- Key elements of the global and local context are described in Chapter 9 – The Global Business Environment and Chapter 10 – National Business Environment.

The main body of work lies in Chapters 11 and 12. In Chapter 11 the critical components of the strategic long term planning conceptual framework are explored, specifically:

The components outlined in part B of Figure 3.1

- 11.4 – World views or scenarios;
- 11.5 – Global assumptions (common long term planning parameters); and
- 11.8 – Contingency planning.

The components outlined in part C of Figure 3.1

- 11.3 – Business strategy definition;
- 11.6 – Value based management;
- 11.7 – Long term planning processes and techniques;
- 11.9 – Valuation and optimisation logic;
- 11.10 – Project value tracking; and
- 11.11 – Supporting capability.

A final consolidation is provided in Chapter 12, covering aspects of the strategic planning challenge, the conceptual framework, the operating context, strategic long term planning and the example application.

A statement of limitations of the research is given in Chapter 13.

The example application is contained in Appendix A, in which aspects of the application of the strategic long term planning conceptual framework at Anglo Platinum Limited are explored over three periods; prior to development and implementation of the framework, during the core development and application period of 2004 to 2007, and then 2008 and beyond. Information utilised in this appendix is limited by the need to restrict disclosure of confidential information relating to the activities of a public listed company. However critical aspects of the application of the conceptual framework are described.

4 LITERATURE REVIEW

Consideration has been given to a limited number of references that highlight areas of relevance to this research.

Mintzberg and Quinn (1991) in *The Strategy Process – Concepts, Contexts and Cases* outline the key characteristics of business strategy through consideration of the “five P’s for strategy” – strategy as a plan, a ploy, a pattern, a position and a perspective. This work highlights the fact that strategy and strategic planning exist at differing levels of the organisation and should be developed and interpreted in terms of overall reach or intent. Understanding constraints and perspectives is thus important.

Morrison *et al.* (1984) in *Futures Research and the Strategic Planning Process* provide an interrelated model for the strategic planning process which consists of six identifiable stages: environmental scanning, evaluation of issues, forecasting, goal setting, implementation and monitoring. This approach highlights the need to integrate information from the external environment in the form of emerging developments with that of the traditionally inward focused planning process.

Porter (1980) in *Competitive Strategy: Techniques for Analysing Industries and Competitors* established a classic framework for strategic industry and competitor analysis. The “five forces” model describes the relationship of new entrants, suppliers, buyers, substitute products/services and rivalry in an industry, thereby defining the likely nature of engagement between the participants in the business environment. This model has had a defining impact on strategic thinking in the business environment with much of the conceptual framework being reflected in subsequent work by a variety of authors.

Kaplan and Norton (2004), in *Strategy Maps* establish the logic of creating customised strategy maps to close the gap between strategy formulation and implementation. Their approach facilitates:

- Strategy clarification and communication to stakeholders;
- Identification of key internal processes that drive strategic success;
- Alignment of investment in people, technology and capital; and
- Exposure of strategy ‘gaps’ so as to allow corrective actions.

The work by Kaplan and Norton demonstrates a widening of perspective to consider ‘softer’ components related to organisational dynamics and systemic dependencies.

The key elements that are commonly held to comprise the concept of strategic planning are identified in the strategic planning category of the *Malcolm Baldridge Criteria for Performance Excellence* (National Institute of Standards and Technology, 2006). In this organisational assessment process, the strategic planning element is considered in categories of strategy development and strategy deployment. Strategy development encompasses customer and market environment, competitive environment, financial and societal risk, human resource capabilities and needs, company operational capabilities, and supplier/partnership capabilities. Strategy deployment focuses on the developed strategy and its implementation (deployment and performance projection).

In the mineral resource industry the emphasis of strategic planning has been placed on economic optimisation of mining units, predominantly open pit operations. A range of companies and products offer strategic mine planning solutions (for example Whittle, Surpac, Gemcom, Minex, Runge) which create the impression that strategic mine planning comprises the activities of life of mine scheduling, economic analysis / optimisation, blend and stockpile optimisation, and schedule balancing. In this context optimisation is generally interpreted as being maximisation of net present value (NPV).

Cut-off grade theory as developed by Lane (1988) provides a rigorous analytical process that leads to a cut-off policy (a sequence of cut-off grades over the life of mine) which will maximise net present value for a specified production rate and set of economic criteria. The approach is highly analytical with limitations to the approach arising in the consideration / optimisation of other objective parameters (other than NPV) and understanding of NPV loss associated with optimisation of these other parameters. Handling of polymetallic deposits, stockpiling and grade-dependent recovery relationships create further computational challenges that can render the approach unwieldy. No consideration is given to the other 'softer' dimensions of strategic planning as highlighted by Kaplan and Norton (2004).

Hall and Stewart (2004) describe a number of methodologies that have been employed to identify optimum mine plans to achieve an objective of 'maximising shareholder value'. A critical observation is that companies tend not to implement a strategy that optimises one of several, often competing, corporate objectives but rather select a strategy that best meets some or all of the competing goals. The strategy optimisation process must therefore be able to identify not only the strategic options to deliver against various objectives but also the trade-offs required to obtain an optimum combination of the various conflicting objectives. Despite identifying the need for consideration of non-numerical optimisation parameters, emphasis is largely placed on mine optimisation aspects such as the effect of increases in cut-off grade and/or mining rates.

Camus (2002) considers the interaction between management of operations and planning in the minerals industry. The economics of mining, the logic of value (NPV) maximisation as optimisation and organisation design to achieve planned objectives are explored. Critically he reinforces the concepts of tactical and strategic planning frameworks and their inter-relatedness.

The gap that exists between classic business strategic planning and strategic mine planning can thus be summarised as follows:

- Business strategic planning has evolved from the consideration of discrete numerical decision parameters in investment decision making, to approaches that include system related parameters in terms of communication, alignment of intent and broader stakeholder interests. This is largely manifested in the work by Porter (1980) which has strongly influenced business practice.

- The commonly applied logic of strategic mine planning is largely focused on asset optimisation at production unit level. Emphasis is placed more on the planning than the strategic elements with broad interpretation of the terms strategic, tactical, short term and long range.

The importance of processes and logic that allow the alignment of capital investment and strategic intent in a systemic approach to investment decision making in the strategic mine planning context is highlighted by Smith and Pearson-Taylor (2006) and Smith *et al.* (2006a, 2006b). These papers are a high level manifestation of the core of knowledge that is expanded and documented in this work.

5 RESEARCH METHODOLOGY

The period from 2004 to 2007 during which the research was undertaken can be described as a period of applied learning, process and systems development, and progressive implementation of the conceptual framework through application in the annual planning cycle.

Elements of the framework have been developed at different rates, during each annual planning cycle, depending on organisational need. There has thus been progressive and iterative improvement in tools and techniques, each year, driven by successes and failures during the previous planning cycle.

The challenge has been to transfer the logic in the conceptual framework into a series of actions that meet the end objective of creating sustainable value whilst operating within mandated strategic bounds, identified constraints, and variable market and economic conditions.

The objective of this thesis is to demonstrate the developmental evolution, implementation and successful adoption of the framework in the work environment.

6 CHARACTERISTICS OF THE PGM MINERAL RESOURCE

The PGM mineral resource is the primary asset underlying value creation through the mining, recovery and sale of platinum group metals. This chapter briefly describes the occurrence and nature of the PGM resource in South Africa, Zimbabwe and the rest of the world. The objective is to facilitate understanding of the nature of the mineral resource and the context in which the Strategic Long Term Planning Conceptual Framework operates, as reflected in part A of the conceptual framework schematic in Figure 3.1.

Platinum group metals (PGMs) are transition metals lying in the d block (groups 8, 9, 10, periods 5 and 6) of the periodic table. PGMs comprise six elements: platinum (Pt), palladium (Pd), rhodium (Rh), ruthenium (Ru), iridium (Ir) and osmium (Os). They have similar physical and chemical properties and tend to occur together in mineral deposits. The PGMs along with nickel, copper and cobalt are closely associated with industrial expansion owing to their application across a range of industries. Physical properties (Table 6.1) such as high density, strength, outstanding catalytic properties, stable electrical properties and high melting points give these metals unique applications in high technology engineering. They are also highly wear and tarnish resistant and as such are well suited to jewellery applications.

Table 6.1 Some physical and chemical properties of PGMs (platinummetalsreview.com)

	Ruthenium	**Rhodium**	**Palladium**	**Osmium**	**Iridium**	**Platinum**
Chemical symbol	Ru	Rh	Pd	Os	Ir	Pt
Density (g/cm^3)	12.45	12.41	12.02	22.61	22.65	21.45
Melting point (℃)	2 310	1 960	1 554	3 050	2 443	1 769
Vickers hardness number	240	101	40	350	220	40
Electrical resistivity (microhm.cm at 0℃)	6.80	4.33	9.93	8.12	4.71	9.85
Thermal conductivity (Watts/metre/℃)	105	150	76	87	148	73
Tensile strength (kg/mm^2)	165	71	17	-	112	14

Ruthenium is primarily used in alloys with platinum and palladium for high temperature - high wear resistance applications such as electrical contacts and jet engine turbine blades. Further industrial application is in thick film chip resistors. Research on medical applications, specifically in cancer treatment, is ongoing.

Rhodium is hard, corrosion resistant and has low electrical resistance. It is usually alloyed with platinum or palladium and applied as a high-temperature and corrosion-resistive coating in electrical contacts, furnace windings, thermocouples, bushings for glass fibre production, electrodes for aircraft spark plugs, and laboratory crucibles. Further application is in autocatalysis and in jewellery as a coating.

The primary application of palladium is in autocatalysis. However further application is in electronics (capacitors, plating and solder), dentistry (crowns and bridges), chemical application (nitric acid production, synthetic rubber and nylon, polyester), fuels cells, coinage, oil refining, medicine (cancer treatment, surgical instruments) and jewellery.

Osmium is rarely used in its pure state owing to the volatility and extreme toxicity of its oxide. The metal is almost entirely used to produce very hard alloys with other metals of the platinum group for fountain pen tips, instrument pivots, turntable needles, and electrical contacts. An alloy of 90% platinum and 10% osmium is used in surgical implants such as pacemakers and replacement of pulmonary valves.

The high melting point, hardness and corrosion resistance of iridium and its alloys determine applicability in high-temperature materials, electrical contacts, high pressure spinnerets and wear-resistant bearings. Iridium is also used as a hardening agent in platinum alloys and has limited application in catalysis and medicine (cancer therapy).

Platinum is the most important of the platinoids with characteristics of high malleability and ductility, infusibility, high oxidation resistance and good electrical and heat conductivity. In the finely divided state, platinum is an excellent catalyst, having long been used in the contact process for producing sulphuric acid. It is also used as a catalyst in cracking petroleum products. There is much current interest in the use of platinum as a catalyst in fuel cells and in antipollution devices for motor vehicles. Platinum clad anodes are extensively used in cathodic anti-corrosion protection systems for large ships and ocean-going vessels, pipelines, steel piers, etc.

Most of the worlds platinum production is derived from South Africa, totalling 79%, whilst Russia produces 12%, primarily as a by-product of nickel recovery, and North America produces 4% of the global Pt (Figure 6.1).

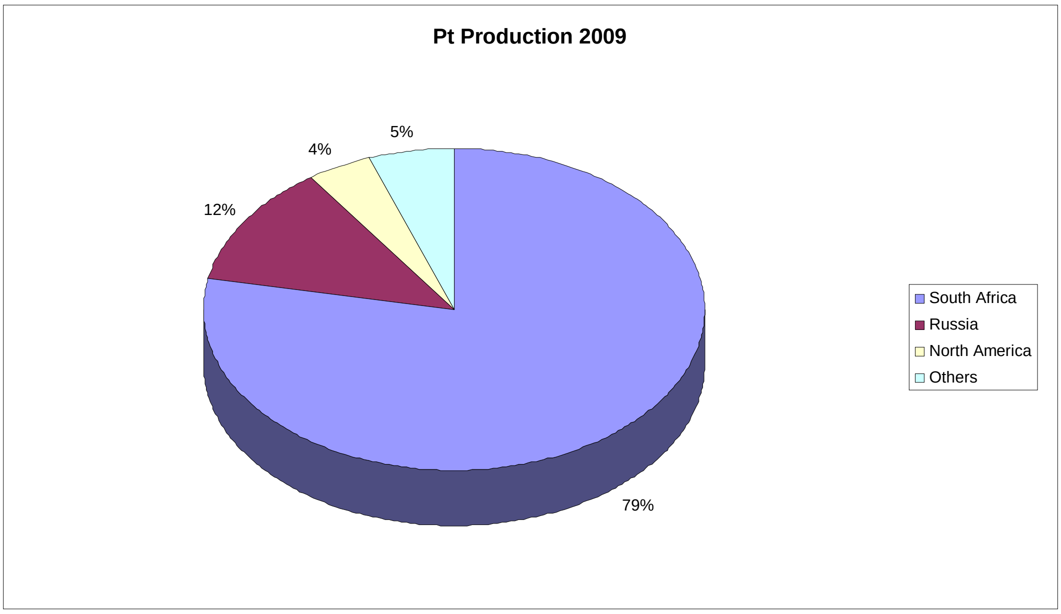


Figure 6.1 Global Pt production (Platinum 2009 – Johnson Matthey)

Platinum's primary occurrence is in base metal ores associated with basic igneous rocks. A large suite of platinum group metal containing chalcogenide minerals is found associated with sulphide mineralisation in ultramafic ores in South Africa in the Bushveld Complex. Platinum nuggets occur naturally as does an alloy of platinum-iridium.

There are four main types of economic PGM resources (Cabri, 2002; Vermaak, 1995):

- Stratiform deposits – where PGMs occur in large Precambrian mafic to ultramafic layered intrusions; major examples include the Merensky and Upper Group 2 (UG2) reefs of the Bushveld Complex in South Africa, the Great Dyke in Zimbabwe and the Stillwater complex in Montana, United States. These are usually considered primary owing to their size (~10 to1 000 Mt) and grade (3 to10 g/t PGMs, ~0.2 to1% Ni+Cu);
- Norite intrusions – where meteoritic impact is considered to have been instrumental in allowing PGM emplacement; the major example is the Sudbury Irruptive Complex in Ontario, Canada (~10 to 1 000 Mt, 1-3 g/t PGMs, ~2-3% Ni+Cu);
- Ni-Cu bearing sills – related to rift structures, allowing concordant intrusive sheets; with examples being the Noril'sk-Talnakh District in Russia and the Jinchuan deposits in China (~10 to 1 000 Mt, 2-15 g/t PGMs, ~3-5% Ni+Cu); and

- Placer deposits – alluvial sedimentary deposits containing coarse PGMs (mainly Pt).

Initial platinum production was from placer deposits in the Urals followed by exploitation, in 1935, of PGM containing copper-nickel deposits on the Taimyr Peninsula in northern Siberia. These remain the most important of Russia's known PGM reserves. The first to be discovered and exploited was the Noril'sk deposit, which lies just south of the town of that name which grew to serve the mining operations. Sperrylite (platinum arsenide) is found with nickel-bearing sulphide ore deposits at Sudbury, Ontario in Canada. Nickel producers in this region produce platinum and palladium as by-products. According to Johnson Matthey (2009) world gross demand for platinum in 2009 was around 7 Moz a year down from ~8 Moz per annum in the period 2005 to 2008.

6.1 South Africa

The Bushveld Complex is the world's largest known platinum deposit and covers an area of approximately 65 000 km^2 in the northern provinces of South Africa. The Bushveld Complex is the largest known mafic-ultramafic intrusion on earth extending some 450 km from east to west and 350 km from north to south, forming a rough saucer shape centred on the village of Bela-Bela. The outcrop area of the complex is over 29 450 km^2 with further sub crops of 36 550 km^2 (Von Gruenewaldt, 1976) with an estimated thickness of 9 km.

A variety of orogeneses have been developed and considered for the Bushveld Complex however current thinking is converging around the concept that the complex was formed by repeated injections and cooling of magma into a massive underground chamber. This magma cooled and crystallised over millions of years forming a layered deposit as different minerals crystallised out at different temperatures and pressures during the cooling process.

The layered sequence is preserved in five major compartments; the eastern Bushveld, the south-eastern Bushveld and the Western Limb which form semi-circular basin like lobes, the far-western Bushveld and the Northern Limb. See Figure 6.1.1.

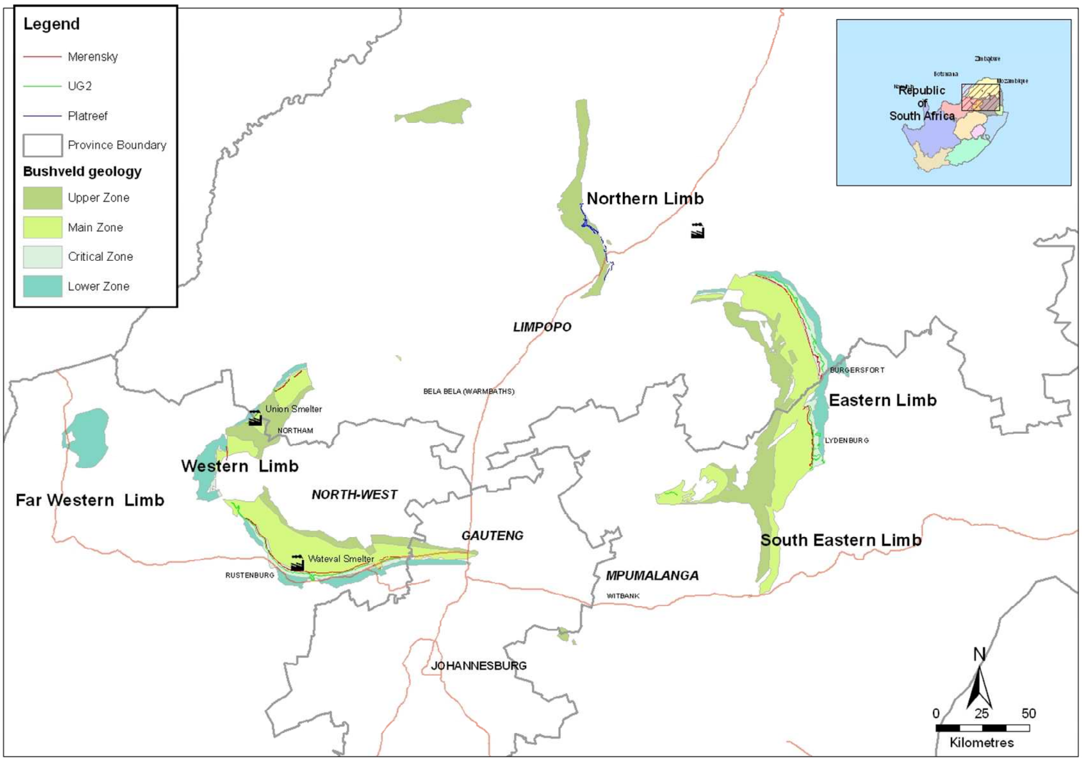


Figure 6.1.1 Bushveld Complex – location (source Anglo Platinum, GIS, 2010)

Economic concentrations of PGMs, in conjunction with significant quantities of chrome, gold, nickel, copper and cobalt, occur principally in three stratigraphic units, the UG2 chromitite (UG2), the Merensky reef (MER) and the Platreef. The stratigraphic column shown in Figure 6.1.2 illustrates the relative positioning of the UG2 in relation to the Merensky reef, and the position of the Platreef.

The Bushveld Complex is estimated to contain approximately 75% of the world's known, estimated, resources of platinum, 52% of palladium, 82% of rhodium and 16% of nickel (Naldrett, 2004). Commercial exploitation of the Bushveld Complex commenced with Merensky mining operations owing to simpler concentrator recovery and smelter characteristics. The UG2 reef has subsequently developed into a significant PGM mineral resource owing to the progressive depletion of much of the best areas of shallow Merensky since commencement of mining. PGM mineralisation grade, in the Merensky and UG2 horizons is typically around 5 g/t (4E) to 7 g/t (4E). The Merensky and UG2 reefs can be identified along two arcs on the eastern and western limbs of the Bushveld Complex, extending from surface, at dips that range from approximately 9 to 18^{o}, to depths of approximately 2 300 m. The Merensky reef and UG2 reef are separated by a vertical distance of between ~16 m (northern area of the Western Limb) and ~400m (eastern Bushveld), depending on location.

On the northern limb of the Bushveld Complex a third PGM bearing stratigraphic horizon, known as the Platreef, occurs. The Platreef is similar in formation to the Merensky reef, however the orebody itself is thicker and not as easily defined. Compared to the rest of the Bushveld Complex, the Platreef is relatively rich in base metals specifically copper and nickel and has a lower platinum / palladium ratio. Typically the Platreef is about 4 g/t (4E) or less in the mineralised zone.

Owing to the scale of the Bushveld Complex and because of its unique character most other layered intrusions are compared with it. The large scale layering forms the basis for a simple subdivision. A characteristic is that to a large extent the layers are laterally continuous, except for minor downward magmatic erosion discontinuities known as potholes. This lateral continuity is a help in the exploration, evaluation (of the economic sequences), mine planning and operation.

The initial intrusion of the Bushveld Complex was by a suite of mafic sills into the floor rocks of the Transvaal Supergroup. Felsic volcanics of the Rooiberg Group and intrusive acidic rocks of the Rashoop Granophyre Suite followed this. The Rustenburg Layered Suite comprises mafic layered rocks ranging in composition from dunite to diorite, intruded beneath the Rooiberg Group and Rashoop Granophyres. Bushveld Granites of the Lebowa Granite Suite intruded these mafic rocks and the overlying Rooiberg Felsites (Kinnaird, 2005). The Rustenburg Layered Suite contains the main economic mineralisation. It comprises a package of rocks 7 – 8 km thick and can be sub-divided into five zones, the Marginal, Lower, Critical, Main and Upper Zones.

The upper Critical Zone of the Bushveld Complex, hosts the largest concentration of PGMs in the world. Apart from the Upper Group Chromitite No. 2 (UG2) and Merensky reef, the zone also hosts the Platreef mineralisation of the northern limb of the Bushveld Complex. The stratigraphic column shown in Figure 6.1.2 (after Schouwstra and Kinloch, 2000) illustrates the relative positioning of the UG2 in relation to the Merensky reef, and the position of the Platreef.

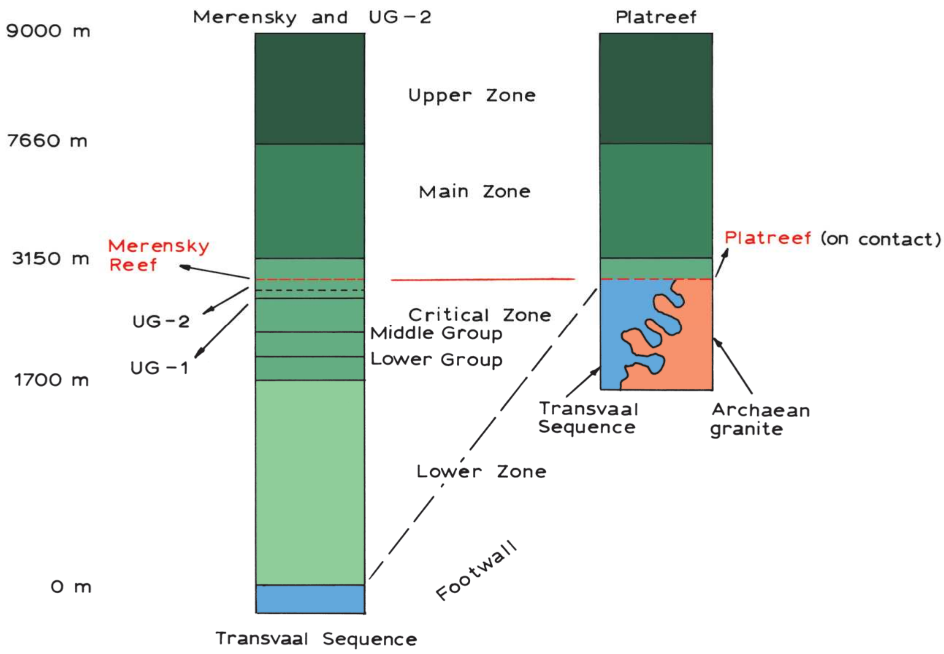


Figure 6.1.2 Stratigraphic column – UG2 reef and Merensky reef location (after Schouwstra and Kinloch, 2000)

Bushveld Complex – mineral resource estimate

A number of estimates, by a range of authors, of PGM mineral resources contained in the Bushveld Complex have been published over the years with a recent summary from Cawthorn (2010) summarised in Table 6.1.1 below.

Table 6.1.1 Bushveld Complex – mineral resource estimates (after Cawthorn, 2010)

	Reserves (Moz)		Resources (Moz)		Deposit (Moz)	
	Pt	Pd	Pt	Pd	Pt	Pd
Merensky reef	55 - 75	33 - 35	524 - 400	302 - 221	345	180
UG2 Chromitite	99 - 116	65 - 69	431 - 404	281 - 354	379	237
Platreef	11 - 10	11	168 - 136	171 - 136	59	66
Total BC deposit					**820**	**720**
Indicative total	165 - 201	109 - 115	1123 - 940	754 - 711	783 - 820	483 - 720

Known platinum mineral reserves therefore represent ~ 20 years at a 2008 peak demand of 8 Moz pa, whilst mineral resources have the potential for an additional ~100 years.

Merensky reef

The Merensky reef has been traced for 300 km around the entire outcrop of the eastern and western limbs of the Bushveld Complex, and to depths of ~5 km. Although the Merensky reef is generally regarded as a uniform reef type, large variations occur in reef thickness, reef composition, as well as the position of the mineralisation. The rock forming minerals of the Merensky reef comprise approximately equal amounts of dark iron-magnesium silicate minerals and lighter calcium-aluminium-sodium silicate minerals (called a feldspathic pyroxenite) under and overlain by thin (5 to 15 mm) often discontinuous layers of chromite concentrations. The total thickness of this package is generally less than 30 cm with dips that range from approximately 9º to 18º. This zone, commonly known as the Merensky pegmatoid, contains the base metal sulphide grains and associated platinum group minerals. The major platinum group minerals are cooperite (PtS), braggite [(Pt,Pd)NiS], sperrylite ($PtAs_2$) and PGE alloys. The rock-forming silicate minerals of the Merensky reef consist predominantly of orthopyroxene (~60%), plagioclase feldspar (~20%), pyroxene (~5%), phlogopite (~5%), and occasional olivine. The base metal sulphides consist of pyrrhotite (~40%), pentlandite (~30%), chalcopyrite (~15%), and trace amounts of millerite (NiS), troilite (FeS), pyrite (FeS_2), and cubanite (Cu_5FeS_4).

The extent and relative amount of PGMs and base metal sulphides appears to be a function of the thickness of the reef, with the highest grades occurring where the reef is thin. Three principal base metal sulphides occur in the Merensky reef. These are, in order of decreasing abundance, pyrrhotite (FeS), pentlandite (FeNiS) and chalcopyrite ($CuFeS_2$). As platinum minerals occur within and associated with these sulphides, the Merensky reef yields substantial amounts of nickel and copper as by-products, together with minor amounts of cobalt and selenium. Whereas the grade of the reef is remarkably constant over extensive strike distances, the composition of the actual platinum group mineralogy is extremely variable even from mine to mine. Grade and metal ratios vary across the Bushveld Complex as indicated in Table 6.1.1., however the Merensky reef can be characterised, typically by a ~60% Pt content, 2/1 Pt/Pd metal ratio, nickel and copper grades of the order of 0.16 and 0.36% respectively. In general the proportions of the precious metals are around: platinum 57%, palladium 25%, gold 4%, iridium 1%, ruthenium 8%, rhodium 4% and osmium 4%.

The geology of the Merensky reef makes it more difficult to mine than the UG2 reef as it is more prone to disruptions from faulting (particularly in the north-western limb), dilution from rolling reef and can be extensively potholed, where the reef abruptly transgresses the footwall rocks. Potholes interrupt the normal mining of the reef. As a result, the Merensky is usually mined using conventional stoping layouts using handheld drills to allow greater flexibility and to prevent removal of unnecessary waste rock. The average cut applied is approximately 100 cm-120 cm.

UG2 Chromitite

The UG2 reef is a platiniferous chromitite layer which, depending on the geographic location within the Complex, is developed some 20 m to 400 m below the better known Merensky reef, with the smallest vertical separation in the western Bushveld and greatest in the eastern Bushveld, at dips that range from approximately 9º to 18º. The chromitite itself is usually 1 m thick but can vary between ~ 0.4m and ~2.5 m. Thin chromitite seams (generally less than 20 cm in thickness) may be present in both the footwall and, more commonly, in the hanging wall rocks. The UG2 consists predominantly of chromite (60 to 90% by volume) with lesser silicate minerals (5 to 30% pyroxene, and 1 to 10% plagioclase). Total PGE values vary from locality to locality, but on average range between 4 g/t and 7 g/t. The base metal distribution follows a similar trend to that of the PGMs, with most of the values occurring in the bottom and top part of the reef. The base metal content of a typical UG2 reef is approximately 200 to 300 ppm nickel occurring as nickel sulphide and less than 200 ppm copper occurring as copper iron sulphide. The platinum group minerals present in the UG2 reef are highly variable, but generally the UG2 is characterised by the presence of abundant PGM sulphides, comprising predominantly laurite (RuOsIr sulphide), cooperite (PtS) and braggite [(Pt,Pd)NiS].

The chromite content is 60% to 90%, with an average Cr/Fe ratio of 1.26 - 1.14 with 43.5% Cr_2O_3. PGM contents are up to 10 g/t 4E (3.6 g/t Pt, 3.81 g/t Pd, 0.3 g/t Rh, 2.3 g/t Au). Cu and Ni are low, generally less than 0.5%. Pt:Pd ratio varies with geographic location.

In contrast to the Merensky reef, the UG2 is relatively uniform and allows for greater use of mechanised equipment, which is more cost effective despite the larger mining width (180 cm to 220 cm). On the downside, the UG2 reef typically has higher chrome content than the Merensky reef. Chrome negatively affects concentrator recoveries and can build up within the furnace, necessitating lengthy downtime for removal.

Platreef

In the northern limb of the Bushveld Complex where the Bushveld rocks are in contact with the floor rocks (that is the Archaean granite and sediments of the Transvaal Sequence), and the Lower and the Critical Zones are poorly developed, a unique type of mineralisation has developed. This reef, known as the Platreef consists of a complex assemblage of pyroxenites, serpentinites and calc-silicates. The different nature of these rocks, compared to normal Merensky reef, is the result of the hot Bushveld magma reacting with the lime-rich floor rocks. An exchange of heat and material between the magma and the floor rocks resulted in the formation of abundant lime-rich minerals (calc-silicates) as well as the serpentinisation of the overlying pyroxenites. Base metal mineralisation and PGM concentrations are found to be highly irregular, both in value as well as in distribution. The mineralisation in places reaches a thickness of up to 40 m. Although the major platinum group minerals consist of PGE tellurides, platinum arsenides and platinum sulphides, there appears to be a link between the rock type and the type of PGMs: serpentinites are characterised by a relative enrichment in sperrylite ($PtAs_2$), whereas the upper pyroxenites are generally characterised by more abundant PGM sulphides and alloy. PGM alloys generally dominate mineralisation closer to the floor rocks. Common base metal sulphides include pyrrhotite, pentlandite, chalcopyrite and pyrite, and although PGMs frequently occur, enclosed in or on grain boundaries of these base metal sulphides, a high association of PGMs with silicate minerals is found in some areas.

The predominantly pyroxenitic Platreef forms the base to the Bushveld Complex north of Mokopane (formerly Potgietersrus). It is the world's third largest resource of PGMs after the Merensky and UG2 reefs. However, it differs considerably from both of these reefs in that it is up to 400 m thick, steep dipping (~45^{o}) and rests directly on footwall metasediments and Archaean basement compared to the Merensky and UG2 reefs which are ~1 m thick layers within a layered sequence of mafic rocks. The Platreef is the site of the world's largest opencast platinum mine at Mogalakwena Platinum Mine and is currently a focus for exploration and expansion.

Visible sulphide mineralisation is frequently encountered in borehole intersections. Generally the predominant sulphide minerals are pyrrhotite, chalcopyrite with minor pentlandite, pyrite and occasionally galena and bornite. According to Lee (1996) and Kinnaird (2005) Cu and Ni range between 0.1-0.25% and 0.15-0.36% respectively. There is an association between visible sulphides and enhanced PGM grade (Lee, 1996) although Kinnaird (2005) has shown that there is no direct correlation between sulphur and PGM content. There appears to be a finite amount of PGM in the system while sulphur may vary, possibly as a result of contamination by country rocks. PGM grades vary from < 2.5 to 15 g/t and occasionally up to 25 g/t (Lee, 1996).

<u>Variability of metal ratios across reefs and compartments</u>

The distribution of PGMs across economic zones and compartments across the Bushveld Complex has significant impact on mine economics and the mix of metal delivered to the market. Merensky resource grades are generally higher on the western limb than the eastern limb. Similarly the northern regions have a marginal grade advantage over the southern parts of each limb. There is no consistent trend relating to the UG2 grades.

Metal ratios (prill splits) and base metal content across the five major regions of the Bushveld Complex are indicated in Table 6.1.2.

Table 6.1.2 PGM (4E) and base metal grade distribution across the Bushveld Complex

	Prill % distribution				Base metal grades	
	Pt%	Pd%	Rh%	Au%	Cu%	Ni%
Merensky Reef - West Bushveld	63.85	27.38	4.47	4.29	0.10	0.24
Merensky Reef - East Bushveld	59.72	30.16	3.12	7.00	0.10	0.23
UG2 Reef - West Bushveld	56.43	31.57	11.32	0.68	0.01	0.10
UG2 Reef - East Bushveld	44.84	45.26	8.35	1.56	0.03	0.14
Platreef	42.62	47.82	3.03	6.53	0.11	0.19

The Merensky reef in the eastern Bushveld differs from that of the western Bushveld by having a slightly higher Pd component. The UG2 reef between the two lobes of the Bushveld follows a similar trend to that of the Merensky reef. The Platreef however has a 1:1 ratio of Pt to Palladium. Pt and Pd on all reefs constitute 80%+ of the total 4E (Pt, Pd, Rh and Au) value.

The base metal values appear to have a similar trend across the Bushveld indicating the association of PGMs and base metals but proving no direct association in the tenor values based on base metal occurrence.

Higher grades and a platinum bias can help explain why the western limb, which is the source of 70% of platinum produced in South Africa, is home to the largest platinum mines in the world. Furthermore, lower grades and a palladium bias suggest that mining on the eastern limb is likely to be relatively less attractive (same costs at a lower revenue) in a scenario where pricing and demand for Pd is less than that for Pt. For example, the Merensky reef on the southern part of the western limb contains approximately 2.3 oz of platinum for each ounce of palladium. This is greater than the 2.1 oz of platinum in the northern section. In contrast, the Merensky reef on the northern part of the eastern limb contains twice the platinum, per ounce palladium, of the UG2 reef in the same area (1.9 vs. 0.9). This creates opportunity, within a portfolio that contains mineral assets across the western, eastern and northern limbs, to schedule production to meet anticipated metal demand mix over time.

Structure and geological losses

The Merensky reef, especially, is well known for its extreme variability, and this not only includes its physical characteristics (Viljoen and Hieber, 1986; Chunnett, 1987), but also its geochemical characteristics (Lee and Brown, 1994; Wilson *et al*, 1999). Additionally the Merensky reef can be extensively potholed. There are essentially two types of pothole, the destructive type and the non-destructive type. The destructive pothole type typically takes on a steep, jagged soup-bowl profile that does not flatten out to any appreciable extent at its base. Within such potholes the reef layer is either partially or completely destroyed (or non-existent). In many western Bushveld potholes of this type, discontinuous pieces of what can be recognised as the reef layer commonly adhere to more stable gradients, while steeper portions may host only a chromitite layer, or no recognisable components of the reef at all. Such an environment may be considered to host abnormal reef, and it is suggested that this type of reef be termed pothole reef (where it exists). Non-destructive potholes, although commonly steep at the edges, typically bottom out onto relatively flat/smooth surfaces (or successive surfaces) of variable extent. These basal environments commonly host normal reef (at least to some extent), easily recognisable as such, and for the most part also mineable, only at a lower than normal stratigraphic elevation (Viljoen and Hieber, 1986; Chunnett, 1987).

Geothermal gradient

The temperature of the working environment in underground mines is determined by the rate at which heat energy is absorbed by the air as it courses through the excavations and is affected by various heat sources. In areas where the rockmass temperature exceeds that of the human body (37ºC), the most significant heat source is the rockmass itself. Beyond this limit, all other sources, usually air auto-compression and heat from machinery, become of secondary significance.

The thermal gradient is expressed in terms of the increase in temperature as a function of depth below surface. Table 6.1.3 indicates generic rock temperature properties used in the South African mining industry as approximations of regional thermal gradients (Patterson *et al*, 1999).

The impact of geothermal gradients on mine design and in particular in the provision of adequate ventilation and air cooling systems is driven by the need to create and sustain a steady environment irrespective of the depth and nature of mining activities. This implies that the introduction of air cooling systems in mines located in the Bushveld Complex will occur at roughly half the depth of a similar mine in the Witwatersrand – excluding the effect of air auto-compression which impacts the two examples equally at depths below 1 500 m. Rock temperatures of the world's deepest platinum mine, Northam, can reach

75ºC at depths of 2 200 m. A typical gold mine on the Witwatersrand will only reach this temperature at ~5 000 m (Patterson *et al*, 1999; Van der Neut *et al*, 2010).

The health and safety of workers is determined, amongst other factors, by the ability to achieve and maintain acceptable environmental conditions in the work place. This requires targeting an air temperature range that must be kept under control within a narrow margin irrespective of the depth. Usually the target temperature envelope extends between (wet bulb) temperatures of 27.5^{o}C and 30.5^{o}C (for a correspondingly acceptable relative humidity range of 50% to 60%). The air cooling system must be adaptable enough to absorb the increasing heat energy released – which is proportional to the difference between the rock temperature and air temperature.

Table 6.1.3 South Africa – regional geothermal gradients (after Patterson *et al*, 1999)

	Surface Ground Temperature (^{o}C)	Temperature Gradient (^{o}C/1000 m)	VRT [T_d] (^{o}C)
Witwatersrand Basin	16.0	9.0	T_d = 16.0 + 9.0 x (d/1000)
Bushveld Igneous Complex	21.5	22.0	T_d = 21.5 + 22.0 x (d/1000)
Free State Goldfields	20.0	14.6	T_d = 20.0 + 14.6 x (d/1000)

In reality, the air cooling requirements arise from a number of factors in addition to rock temperature gradients. Other factors that will add to the heat load include air auto-compression (which increases linearly with increasing depth) and the type and extent of mining operations that would typically include the degree of scatter of mining operations, the type of machinery used and the use of backfill.

Therefore the variation in rock temperature with depth affects aspects of operations not only in terms of safety and productivity but also in terms of operational costs since mechanical cooling is required to maintain the design temperature conditions.

The cost of cooling the working face at depths greater than ~2 500 m may prohibit development of deeper mineral resources, impacting long term supply and pricing.

6.2 Zimbabwe

PGM mineralisation in Zimbabwe occurs in the Great Dyke structure. The Great Dyke is a layered intrusion similar to the Bushveld Complex, running north-east to south-west through the centre of Zimbabwe. The Great Dyke is estimated to contain about 9% of the world's known platinum resource. Like the Bushveld Complex, repeated magma intrusions filled a series of underground chambers, creating three identifiable sequences or layers. The shallowest sequence of the original intrusion has been removed through erosion, exposing a layer within the second sequence known as the Main Sulphide Zone (MSZ). The MSZ is the target reef of platinum mines along the dyke.

The P1 pyroxenite is host to three sulphide zones known as S1, S2 and S3. The uppermost of these, the S1 zone, is host to the Main Sulphide Zone (MSZ) reef. The MSZ reef itself consists of the lowermost sulphide concentration of the 2 m to 3 m wide S1 zone, and appears as a variably visible interstitial sulphide-rich layer of between 10 cm and 30 cm in width, hosted by the uppermost portion of the ~200 m wide P1 plagioclase pyroxenite. While an immediate upper contact of this lower sulphide concentration may not be obvious due to overlying sulphides that constitute the remainder of the S1, its lower contact is usually discernible and is used as a zero datum for sampling and mining. Somewhat unlike the PGM reefs of the Bushveld Complex, the MSZ reef is remarkably similar stratigraphically, petrologically and geochemically throughout the entire Great Dyke. Also, unlike the Merensky and UG2 reefs of the Bushveld Complex, which are highly visible and easily distinguishable from their adjacent stratigraphy, the MSZ reef consists only of a relatively thin, variably visible intercumulus sulphide layer within plagioclase pyroxenite, and is both overlain and underlain by relatively sulphide-poor plagioclase pyroxenite. Commonly a second sulphide layer, virtually identical in appearance, occurs at approximately 1.2 m above the MSZ reef. This layer is effectively PGM-barren. Unlike the Merensky and UG2 reefs, potholes do not occur in the MSZ. (Wilson, 1992a, 1992b; Wilson *et al*, 1989; Wilson and Tredoux, 1990; Wilson and Chaumba, 1997).

6.3 Global

6.3.1 Russia

Although most of the PGMs recovered in Russia are a by-product of nickel-copper mining, some primary platinum does occur in placer deposits in the Ural Mountains and Siberia, and is mined by small private production companies. Platinum accounts for 90% of PGM production from these sources. After platinum, iridium is generally the most common PGM from Ural Mountain placers, accounting for up to 10% of the PGM content of these deposits (Roskill Information Services Ltd., 1999, p. 49).

Significant quantities of PGMs are recovered from nickel-copper sulphide deposits in the Noril'sk-Talnakh area of Siberia. A general location map is provided in Figure 6.3.1. MMC Norilsk Nickel produces more than 95% of the country's PGM (Bond and Levine, 2001). The Russian Government has treated production data for PGMs as a state secret since 1995. Although a new law, signed November 11, 2003, was expected to make Russian PGM production and trade data available by March 2004, release of the data has since been delayed. It is known, however, that the Oktyabrskiy mine at the Noril'sk complex accounted for almost 60% of PGM production in 1999, the Komsomolskiy underground mine accounted for more than 15% of PGM production from the Noril'sk region, the Taymirskiy underground mine accounted for more than 10%, and the Zapolyarniy underground mine accounted for more than 7% of Russian PGM production in 1999 (Piven, Konovalov and Shtern, 1999).

Figure 6.3.1 Russia – major platinum deposit location

With the long history of nickel-copper production in the Noril'sk-Talnakh region and the relatively low recovery of PGMs from established mines, mine tailings and stockpiles are becoming an increasingly important source of PGMs in Russia, given high PGM prices. MMC Norilsk Nickel recently began recovering PGMs from stockpiles, and additional concentrator capacity was being adapted to process stockpiles with a reported average

PGM content of 8 g/t. These stockpiles are reported to contain up to 600 000 kg of PGMs (Interfax Mining and Metals Report, 2001b).

6.3.2 North America

Canada

Primary (not recovered as a by-product) production of PGMs in Canada comes from North American Palladium Ltd (Lac des Iles Mine), which began production in 1993 as an open pit mine that produced a concentrate rich in palladium but also contained platinum and small amounts of base metals. Further exploration in the area is being carried out to define resources of similar occurrences. Although the average PGM grade at Lac des Iles is relatively low, generally less than 2 g/t, the PGMs are not confined to a narrow reef as found in South Africa but occur throughout extensive areas of mineralisation close to the surface. This makes it possible to mine the deposit using low-cost, open pit mining techniques (Johnson Matthey Plc, 2001, p. 20).

However PGMs are recovered in Canada by Inco Limited and Falconbridge Limited as by-products from the mining and processing of nickel-copper ores. Most Canadian PGMs are recovered from nickel-copper ores mined in the Sudbury Basin in central Ontario, although small amounts are produced from Inco's nickel operations in Thompson, Manitoba and Falconbridge's Raglan nickel-copper mine in Quebec. The typical palladium-to-platinum ratio associated with Sudbury ores is 1.16 to 1 with minor amounts of other PGM included in the ore (Inco Limited, 2001, p. 42). Inco Limited continues to be a leading PGM producer in Canada, reporting deliveries attributed to Canadian operations of approximately 7 000 kg palladium, 5 900 kg platinum, and 500 kg of other PGMs in 2002. Inco's mining operations send concentrates to the Copper Cliff complex in Ontario for initial processing; the concentrates are then shipped to Inco's PGM refinery in Acton, United Kingdom. The Lac des Iles Mine of North American Palladium Ltd. produced approximately 11 000 kg of palladium in 2002. Falconbridge Limited contributed a small amount of Canadian PGM production from by-product production from the Raglan nickel-copper mine in Quebec and by-product production from the Sudbury Basin nickel-copper mines, although production figures are not published.

The Raglan nickel-copper mine began operations in 1998. The palladium-to-platinum ratio in the Raglan ore is estimated to be about 3 to 1 (Johnson Matthey Plc, 2001, p. 19). Raglan concentrate, from the Strathcona mill, is shipped to the company smelter at Sudbury; initial nickel-copper matte is shipped to the company's refinery in Norway where nickel, copper, PGMs, and other metals are recovered (Fogg and Cornellisson, 1993, p. 16). Falconbridge is reported to have the capacity to produce up to 500 kg/yr of platinum and 1 100 kg/yr of palladium (Metals Economics Group, 2000), although actual production levels are much lower.

In addition to PGM recovery from nickel-copper operations, limited amounts of PGMs are recovered from materials imported by the CCR Division of Noranda Inc. in Montreal, Quebec, and at the nickel refinery of Sherritt Gordon Mines Limited at Fort Saskatchewan, Alberta. Noranda also recovers PGMs from domestic and imported scrap. As with Canadian production by Inco and Falconbridge, this material is refined in Europe (McCutcheon, 1996, pp. 45.1-45.14).

USA

U.S. PGM production comes from the Stillwater Complex near Nye, Montana. In 2003, following U.S. Federal Trade Commission concurrence, MMC Norilsk Nickel purchased 51% interest in Stillwater Mining Company, which operated the Stillwater and East Boulder mines (with an option to increase its interest to 55%). The Stillwater Complex is an igneous layered intrusion that is geologically similar to the Bushveld Complex. The reserves of the Stillwater Complex are found in the Johns-Manville (J-M) reef, which contains PGM grades averaging about 20 g/t and a typical palladium-to-platinum ratio of slightly more than 3 to 1. As of December 31, 2002, Stillwater Mining Company reported proven and probable reserves of 25.3 Moz of PGMs with an additional delineated resource of 67 Moz of PGMs (Stillwater Mining Company, 2002, p. 8). Resources for the East Boulder mine, which began production in 2002, were included in this resource estimate.

The J-M reef has been drilled to a depth of about 1 800 m, but geologic and geophysical evidence suggests that it continues downward and perhaps flattens to the north. The higher grades and thicker zone of mineralisation make the deposit amenable to higher extraction rates and lower underground production costs than the Bushveld mines. Even so, the high-grade ore is not continuous throughout the J-M reef (Dyas and Marcus, 1998).

Current PGM production is achieved from two mines (Stillwater and East Boulder) in the Stillwater Complex. During 2002, the Stillwater Complex produced approximately 11 800 kg (379 koz) of palladium and 3 500 kg (113 koz) of platinum, compared with approximately 12 100 kg (388 koz) of palladium and 3 600 kg (116 koz) of platinum in 2001. The East Boulder mine commenced production in 2002 and produced 3 000 kg (97 koz) of palladium and 900 kg (28 koz) of platinum in 2002 (Stillwater Mining Company, 2002, p. 8). The East Boulder mine was scheduled to reach its full production capacity of 14 000 kg/yr (450 koz/yr) of palladium and platinum by 2006.

6.3.3 China

Jinchuan Group Limited (JNMC) is a large integrated non-ferrous metallurgical and chemical engineering enterprise engaged in mining, concentrating, metallurgy and chemical engineering. It produces nickel, copper, cobalt, rare and precious metals and also some chemical products such as sulphuric acid, caustic soda, liquid chlorine, hydrochloric acid and sodium sulphite, together with some further processed nonferrous metals products. Their output of nickel and platinum group metals respectively accounts for more than 90% of the total production in China. Jinchuan Group Ltd is the largest producer of nickel and cobalt in China. Jinchuan Group Ltd has had an annual production capacity of 130 000 t of nickel, 200 000 t of copper, 6 000 t of cobalt, 8 000 kg of platinum group metals and 1 200 000 t of chemical products. (Jinchuan Group Limited, 2010, [online]).

The Jinchuan intrusion, situated in Gansu province, China, is an ultramafic dyke-like body emplaced in the Longshoushan uplifted terrain on the southwest margin of the Sino-Korea platform. The intrusion is 6 km long, 350 m wide and hosts a major Ni-Cu sulphide deposit. It comprises three sub-chambers: the west, west-central and east. The two western sub-chambers are narrow and deep, and both are laterally zoned from dunite in the core through Iherzolite to olivine pyroxenite toward the margins. The eastern sub-chamber is shallow and wide, and it shows vertical stratification grading from dunite at the base upward into Iherzolite and plagioclase Iherzolite, then back to Iherzolite at the top.

The two western sub-chambers of the Jinchuan intrusion represent the main conduit to the original magma chamber and their zoning was formed by flow differentiation. The eastern sub-chamber probably represents a higher level of the magma chamber, where crystallisation was marked by convection and periodic replenishment. After consolidation, the Jinchuan intrusion was tilted to the east so the deeper parts of the western sub-chambers are now exposed to the same erosion level as the shallower part of the eastern sub-chamber (Chai and Naldrett, 1992).

6.3.4 South America

Brazilian PGM production is derived primarily from the Fortaleza nickel-copper-PGM-gold mine, which in 1997 began production of 10 000 t/yr of nickel matte that contained PGMs. The nickel matte is exported to the OM Group Inc. Harjavalta nickel refinery in Finland for PGM recovery. Reserves are reported to contain 7 300 kg of PGMs (Roskill Information Services Ltd., 1999, p. 29). Caraiba Metals S.A Camacari copper refinery in Brazil is also reported to produce 150 kg/yr of platinum and 400 kg/yr of palladium. Recovery of PGMs from other copper deposits in Brazil has been proposed, but to date none of these projects have come to fruition.

Colombia has produced PGMs since the 16th century. PGM production in Colombia, primarily platinum, is derived from alluvial placer deposits worked by artisanal miners. In some places, the deposits are associated with the production of gold. Colombia produced about 430 kg of PGMs in 1998, 310 kg of PGMs in 2000 and 650 kg of PGMs in 2001 (Torres, 2004). Production is sporadic but was reported to have reached almost 2 000 kg in 1992.

6.4 Contribution to the Conceptual Framework

The ability to respond to variable metal demand over long time periods and create strategic planning flexibility, is dependent on being able to source production of PGMs from mineral assets with different metal ratio characteristics. Thus:

- Variability of metal content by geographical region is a strategic planning element that allows production portfolio development and creates flexibility to meet varying PGM demand over time;
- Similarly reef mix (UG2 / Merensky / Platreef / MSZ) will impact saleable metal ratios and cost of production;
- The cost of production in the Bushveld Complex, despite normal increases with depth and distance from infrastructure, has a step change at ~750 m below surface owing to the need to introduce refrigeration and cooling; and
- Holding mineral assets outside of the Bushveld Complex, apart from reducing sovereign risk, creates longer term strategic flexibility, owing to the marked differences in Pt/Pd ratios, and is beneficial in reducing long term mineral asset portfolio risk.

7 THE PLATINUM VALUE CHAIN

This chapter considers the key elements of the platinum mining industry value chain. The objective is to describe the major elements within the value chain and highlight areas of strategic planning flexibility. The nature of the value chain is integral to the understanding of the characteristics of the market (Chapter 8) with both elements being reflected in part A of the conceptual framework schematic in Figure 3.1.

Value creation in the platinum mining industry can be considered across a value chain extending from exploration through to fabrication and final use. Value addition beyond refined metal sales has not been considered on the basis that the prime consideration, of this work, is the strategic long term planning of metal production not value enhancement through further metal beneficiation and product development.

A basic industry value chain is indicated in Figure 7.1. It is important to note that the major industry producers tend to be integrated along the value chain and have considerable assets in the mining and processing value chain elements.

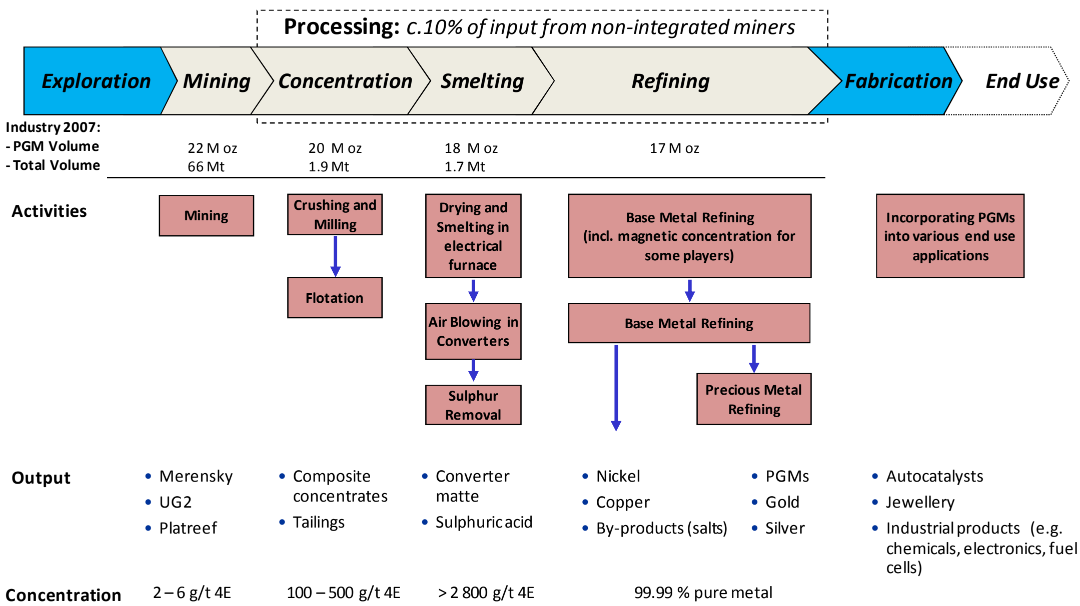


Figure 7.1 Platinum industry value chain

Within this value chain the greatest opportunity to vary production lies in the mining activity owing to the greater number of sources of metal. This is indicated in Figure 7.2 for a hypothetical multi mining right, vertically integrated PGM producer.

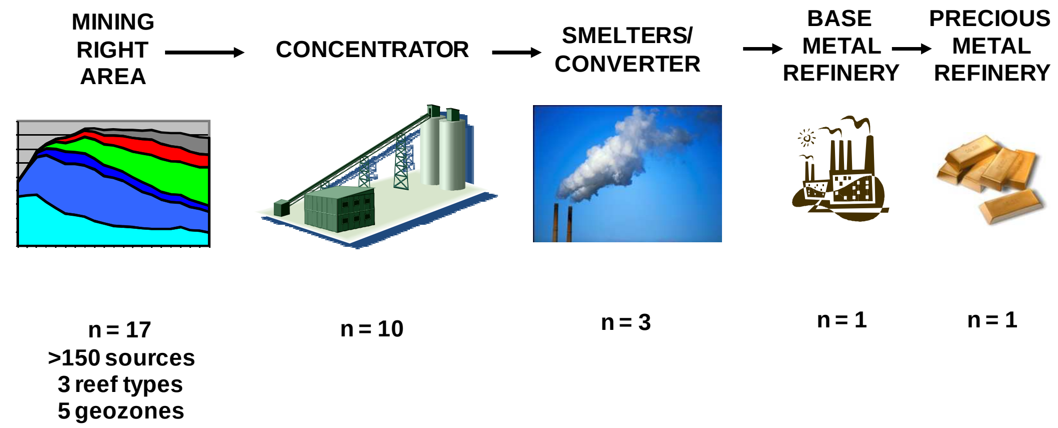


Figure 7.2 PGM mining and process chain – flexibility lies in the mining portfolio

Similarly indicative value chain profitability, across application in autocatalysis, jewellery and fuel cells (as an industrial application) based on 2007 public domain information is indicated in Figure 7.3.

	Autocatalyst		Jewellery		Fuel Cell	
	Value Chain	2007 Market Op. Profit	Value Chain	2007 Market Op. Profit	Value Chain	2007 Market Op. Profit
Miners	PGM Mining	$4.5B c. 65%	PGM Mining	$0.8B c. 55%	PGM Mining	$49.8M c. 80%
	PGM Processing	$0.8B c. 10%	PGM Processing	$0.2B c. 10%	PGM Processing	$13.4M c. 20%
Fabrication and Assembly	Substrate Design and Fabrication	$1.3B c. 20%	Fabrication	$0.1B c. 10%	Catalyst Component (Electrode) Manufacture	($6M) (c. 10%)
	PGM Wash Coating		Semi-Manufacturing (Design, Casting, Stamping, Machining)		Technology Development & Fuel Cell Design	
	Catalytic Converter Design		Manufacturing			
	Catalytic Converter Canning / Assembly		Marketing & Distribution	$0.1B c. 5%	Fuel Cell Fabrication	
Installation & Sales	Exhaust System Assembly and Installation(1)	$0.5B c. 5%	Wholesale and Retail Sales	$0.5B c. 30%	System Integration and Installation(1)	$6M c. 10%

Source: Annual reports : Anglo Platinum, Impala Platinum, Johnson Matthey, Heraeus, Umicore, Ballard Power Systems, Tiffany, Zale

Figure 7.3 Indicative value chain profitability – three generic product streams (after Anglo Platinum Limited, Industry and Competitor Analysis 2007)

On this basis the bulk (~70%) of operating profit will arise from mining and processing activities rather than from application and retail.

7.1 Exploration

For a mature producing operation, exploration activities are usually focused on Brownfield exploration which is the process of improving mineral resource estimates in areas adjacent to existing operations, into which mining will progress. Greenfield exploration encompasses activities to identify and acquire new mineral assets, typically covering aspects of area identification, target generation, data acquisition and analysis, followed by definition of a mineral resource estimate. Greenfield exploration activities are structured according to the strategic intent of the organisation and the composition of the existing mineral asset portfolio. Exploration activity is crucial to the value chain in that it is the primary mechanism, excluding acquisitive activities, for replacement of depleted mineral resources.

7.2 Mining

The objective of this section is to briefly describe the more commonly applied mining methods used in the mining of PGM mineral resources. Mining operations comprise either surface or underground methods. Surface operations tend to be limited to the outcrop of UG2 and Merensky with the exception of the Platreef where sufficient mineral resource width allows significant open pit operations.

Surface mining tends to be less capital intensive and involves shorter lead-times to production than underground mining. For these reasons, it is often an important initial phase of an underground mine's development, as cash flows from early production can be used to subsidise ongoing capital-intensive underground development costs.

Underground operations are typically based on shaft access, either decline or vertical, to access mineral resources at depths ranging between 50 m to 2 200 m. Stoping methods range from fully mechanised trackless mechanised mining (TM3) through to conventional narrow reef tabular stoping with hand held pneumatic rock drills. The extent of mechanisation varies across operations and depends primarily on geological factors of reef width, dip and structural elements specifically localised faulting or other disruptive geological features. Despite significant efforts to develop and implement non explosive rock breaking techniques, primary rock breaking is conducted using explosives.

A range of underground mining methods are used in the South African platinum mining industry to extract the narrow reef tabular platinum deposits of the Bushveld Complex. These underground mining methods fall into three broad categories, namely conventional, mechanised and hybrid mining. Conventional mining includes up-dip, down-dip and breast mining. Mechanised mining includes room and pillar, room and pillar with T-cut, extra low profile (XLP) and continuous rock cutting technology. Hybrid mining includes two-drive and three-drive on-reef scattered breast mining. Hybrid methods were developed to maintain the advantages of conventional mining on reef such as low dilution and a high shaft head grade, while adding the many advantages of mechanised development such as faster development rates and safer operating procedures (Egerton, 2004).

7.2.1 Underground – conventional (scattered breast) mining method

Crosscuts from the shaft or other access system are developed, at different levels usually ~40 m to 50 m towards the reef plane. Footwall drives are then developed, on strike, from these crosscuts, at depths of between 20 m and 80 m (depth dependent) below the reef plane. Development of the orebody is then done on a grid pattern of footwall drives spaced ~210 m to 240 m apart on dip and raises spaced ~150 m to 200 m on strike. Approximately every 200 m a stope cross-cut is developed to reef from which the raise is developed on dip, to hole into the next level. Ore passes (boxholes) out of the stope cross-cut are developed to intersect the reef in the raise. The shoulders of the raise are ledged in 6 m on either side, and supported, typically with pre-stressed timber units and advanced strike gullies (ASGs) established. Breast panels, usually about 30 m in length are then mined on strike. Local support pillars, approximately 4 m by 4 m, with a 3 m ventilation holing between, are left at the top of each stoping panel. Temporary support is installed in the form of mechanical props down the face between the permanent support and the panel face. A combination of timber elongates and roof bolts is used to provide local support in the stopes. Regional stabilising pillars are incorporated into the mining layout to provide regional stability. In shallow mining areas in-stope pillars are designed to support the overburden to surface whilst in deeper areas in-stope crush pillars are designed to support the tensile zone between regional pillars and to prevent back breaks over-running adjacent panels. Panels are cleaned by face scraping down-dip into an advanced strike gully (ASG) and then along strike to the raise, over a grizzly, and into an ore pass. The ore is trammed by electric or diesel powered locomotive and hoppers from the boxholes to the shaft orepass system and hoisted to surface for processing.

Conventional mining is labour intensive and relatively costly but it is inherently flexible (to cater for unanticipated geological complexities) and allows the greatest control of dilution.

7.2.2 Underground – trackless mechanised mining method (TM3)

TM3 is an adaption, for hard rock mining, of layouts that have traditionally been applied to coal mining. This form of room and pillar (bord and pillar) mining is best suited to a reasonably wide and flat dipping reef with best results being achieved with reef widths between 1.8 m to 2.3 m with efficiency improving with increased reef width. However there are limited mineral resources that meet this criterion and equipment has been progressively modified to allow mechanised mining down to widths of 1.2 m. However because all access and development is on reef, all additional waste mined is integral to the mining process and cannot be readily separated. This adds to the dilution, and shaft head grades are lower than for conventional mining.

Access to the orebody is normally via a large single decline developed from surface whilst in deeper or older mines, access is usually from a vertical shaft crosscut. The decline is equipped with an ore hauling conveyor belt, power supply, compressed-air pipes, service water pipes and pump columns, and serves as a roadway and the major intake airway. When the mineable reef position is reached, the primary decline splits into a cluster of five separate declines normally about 6.5 m to 9 m wide by about 2 m to 2.5 m high. The centre decline is equipped with a large capacity conveyor belt, which feeds directly into the decline tip on surface (or shaft). This conveyor belt can extend over many kilometres as one conveyor ‘piggybacks’ onto another. The declines immediately on either side of the conveyor are used as roadways for trackless machinery and personnel. The declines, on either side of these equipment / personnel roadways are used as return airways during the development phase and intake airways when stoping starts. There are connecting crosscuts between declines about every 70 m on dip. The cluster is developed until nine rooms (strike drives or roadways) have been established on dip. The fifth room on dip, i.e. centre of the nine rooms, is equipped with a conveyor belt, which is extended on strike as the mining advances. This conveyor belt tips onto the conveyor belt in the conveyor (centre) decline. The strike conveyor belt in the fifth room is advanced every 25 m. LHD units tip the run-of-mine rock, onto a feeder situated at the front end of the conveyor belt. Each strike conveyor belt services a section of 150 m to 190 m on dip.

As a mechanised mining method, trackless machines perform all operations:

- Face drilling is done using electro-hydraulic drill rigs;
- Hanging and sidewall support is done using electro hydraulic roofbolters and scalers;
- Charging-up is done with purpose-designed emulsion explosive charging-up vehicles;
- Face cleaning is done with LHDs; and
- Specially designed vehicles are used for personnel and materials transport.

The mining cycle is structured so as to distinctly separate the operation of the various activities of the primary production equipment during a shift, as follows:

- Blasting takes place at the end of day shift and night shift. Thus there are two blasts per day; and
- On a three shift per day cycle; six panels are cleaned, six panels supported and six panels drilled and blasted, aiming for 2.9 m advance per blast.

For low profile equipment the mine design is normally based on a 9 panel per strike section with 6 m to 12 m face length for the bord and split on both single and dual seam mining methods. In the strike sections the tips are moved forward or re-established after every fourth split +/- 50 m. Depending on the geotechnical conditions the roof support strategy may either include roof bolts, cable anchors or a combination.

The fundamental premise in TM3 is that gains in productivity (resulting in reduced cost) outweigh increases in dilution, associated with the larger excavations to accommodate equipment, and reduced overall percentage extraction.

7.2.3 Underground – hybrid mining method

The method is a combination of mechanised bord & pillar and conventional mining techniques. Underground workings are accessed by vertical shaft or decline systems dependent on the nature of orebody or history of operations.

Fully mechanised room and pillar systems at narrow stoping widths result in high dilution and reduced mill feed grade. To keep many of the advantages of mechanisation it is necessary to hybridise the mining method by introducing elements of conventional narrow tabular orebody mining, typically all or part of the stope drilling, blasting and cleaning is as per conventional stoping. Trackless mining equipment is utilised for developing advanced strike drives (ASDs) and dip roadways, and to deliver material to the stope; viz. development is fully mechanised, whilst stoping operations are done conventionally. A stoping production unit would typically comprise of a centrally located strike conveyor with three panels, two above and one below the conveyor. The footwall development usually leads the mining faces by about 100 m to allow for geological data collection and diamond drilling as necessary. The information gathered from this drilling provides structural and geological information on the mining areas ahead of the mining faces. This information is used to proactively plan for structural and geological complexities.

A range of variants to this approach exists, for example the inclusion of conveyors in footwall haulages to eliminate the use of locomotives and hopper transportation.

The system is more labour intensive than room and pillar mining, as all stoping operations are done conventionally. Waste dilution tends to be lower than for room and pillar mining but overall efficiencies and utilisation of labour are poorer. The key challenge in the effective implementation of this mining method is ensuring an appropriate match between the stoping and development activities.

7.2.4 Surface mining – open pit operations

It is generally considered that surface mining is more advantageous than underground mining in recovery, grade control, economics, flexibility and safety. However the application of this mining method is dictated by the physical characteristics of the mineral resource with both the Merensky reef and the UG2 chromitite not being suitable, primarily owing to narrow reef width. Apart from initial shallow (40 m highwall), contract mined, open pits to facilitate early cash flow from Merensky and UG2 outcrops, only one permanent open pit mine operates in the South African industry (Mogalakwena Platinum Mine) exploiting the Platreef.

Open-pit mining is a surface mining operation. During the mining process, the surface of the land is excavated, forming a deeper and deeper pit until it is no longer economically viable. Consideration must then be given to a shift to underground mining. The final size and shape of this open pit is subject to continuous optimisation, being driven by changing economics, geotechnics, mining technology and metallurgical technology and capacity.

Mogalakwena operates in a hard rock environment so drilling and blasting techniques are applied to fragment the waste and ore bearing rock. Heavy duty, large capacity shovels are used to load the fragmented rock into large capacity haul trucks. The pits are planned using a sequenced cutback methodology which maximises the NPV from each individual pit.

As in all open pit mines the slope angle of the pit wall is crucial to the long term stability of the operations so monitoring as well as the gathering and analysis of geotechnical data is of paramount importance. Slope designs are based on a combination of empirical data and judgement, kinematic analysis, numeric analysis, rock fall analysis and a full cost/benefit slope optimisation and risk assessment. These slope optimisations are revised each time a changing trend is observed in the geotechnical and/or geological data, as well as each time the mining economic parameters or acceptable risk criteria undergo any significant change. The overall slope angles at Mogalakwena are achieved by both single and double benching. This establishes catchment berms for every bench face leaving a 10 m to 30 m high face (highwall) in between berms.

Wall control blasting is practised throughout all pits at Mogalakwena. This is achieved by means of pre-splitting, trim blasting, buffer blasting within all trim blasts, use of electronic detonation and careful design of the timing and initiation of the blasting sequence.

The pits are accessed via ramps designed according to the operating requirements of the truck fleet. Generally ramps are 30 m to 40 m wide and are mined at a 10% gradient. This may change locally to suite slope stability and operational requirements. The ramp systems generally include redundancy in the form of multiple accesses to the pits and cater for main haulages on both the hangingwall and footwall sides of the pits. The pits are dewatered via sumps and as mining continues to greater depths alternative dewatering systems (such as toe-drains) are implemented to ensure that the slopes remain as dry as possible.

After a blast, hydraulic or rope shovels are used to load the muck pile into large capacity haulers. Depending on the material type, these trucks transport the broken material to either waste dumps, stockpiles or into a primary crushing facility, all of which are located in close proximity to the operation.

Surface mining operations are an effective means for utilising lower grade, high mineralisation width mineral resources. However, given the scale, duration and visibility of mining operations, they have a large social impact. The major challenge facing current and future mineral rights holders, where open pit mining would be the preferred exploitation route, is mitigation of the social and environmental impacts.

7.3 PGM recovery processes

PGMs occur as associations with the base-metal minerals or as discrete particles within the gangue minerals. The range of minerals present, their relative densities, discrete particle size and association, present a challenge in the optimisation of PGM extraction processes.

Primary producers of PGMs extract and refine the metals in a series of metallurgical plants. The extraction processes can be divided into a number of different stages:

Concentration: Ore from mining operations is crushed and milled prior to being concentrated by gravity and flotation techniques, which result in a PGM and base-metal-rich flotation concentrate for smelting.

Smelting: The flotation concentrate is processed further by pyrometallurgical concentration which produces PGM-rich copper-nickel matte.

Base metal refining: The base metals are hydrometallurgically separated from the matte, with concentration of residual PGMs.

Precious metal refining: The PGMs are separated and purified using solvent extraction techniques.

This is summarised and represented in Figure 7.3.1.

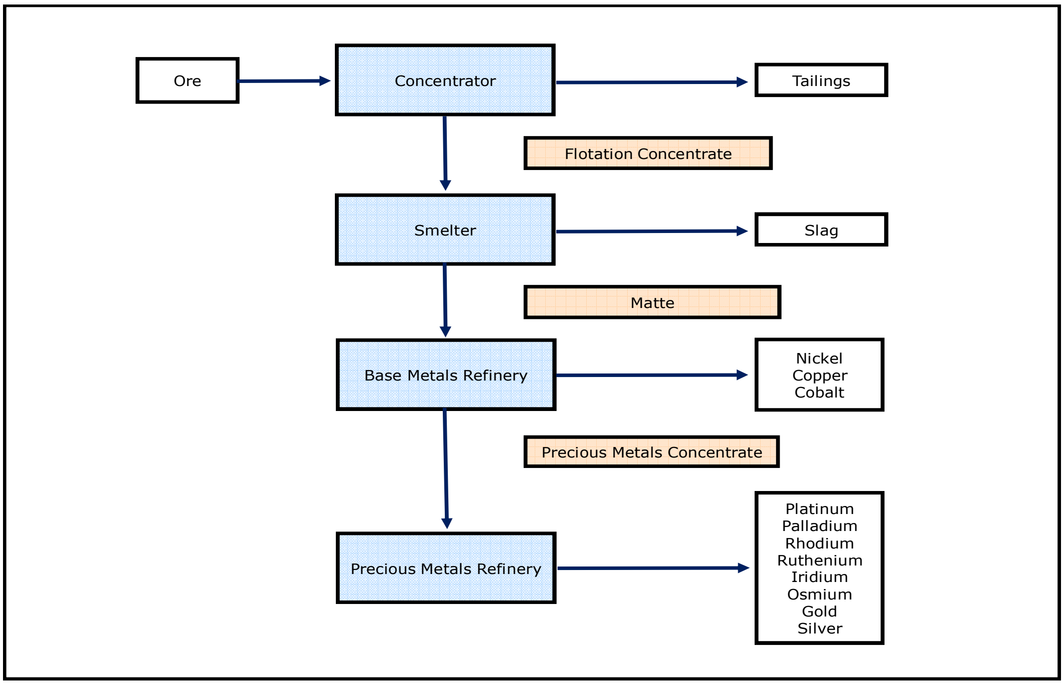


Figure 7.3.1 Simplified PGM extraction block flow diagram

7.3.1 Concentration

Concentration is the initial process, after mining, to separate waste material from the PGM rich ore, thereby increasing the concentration of PGMs for subsequent treatment. Concentration comprises core components of crushing, grinding and flotation. These processes can be enhanced by the inclusion of dense media separation (DMS), and tailings retreatment.

Typically a concentrator consists of a crushing plant with primary and secondary crushers feeding the primary mill. The primary mill is usually operated in a closed circuit with a hydrocyclone, with the cyclone overflow feeding the primary rougher floatation circuit. The primary rougher concentrate is fed to cleaner floatation cells with the cleaner concentrate being fed to a final concentrate storage facility. The primary rougher tails stream is fed to a secondary ball milling circuit with the product stream being fed to the secondary rougher flotation circuit. The secondary rougher concentrate is fed to cleaner and re-cleaner flotation and the re-cleaner concentrate fed to the final concentrate storage facility. The secondary rougher tails are usually fed to the final tailings disposal facility however some studies have indicated that there may be economic merit to the addition of a tertiary milling and grinding circuit dependent on mineralogy, for tailings re-treatment.

A typical concentrator flow sheet for a “Mill-Float 2” arrangement excluding tertiary tailings re-treatment is indicated in Figure 7.3.2

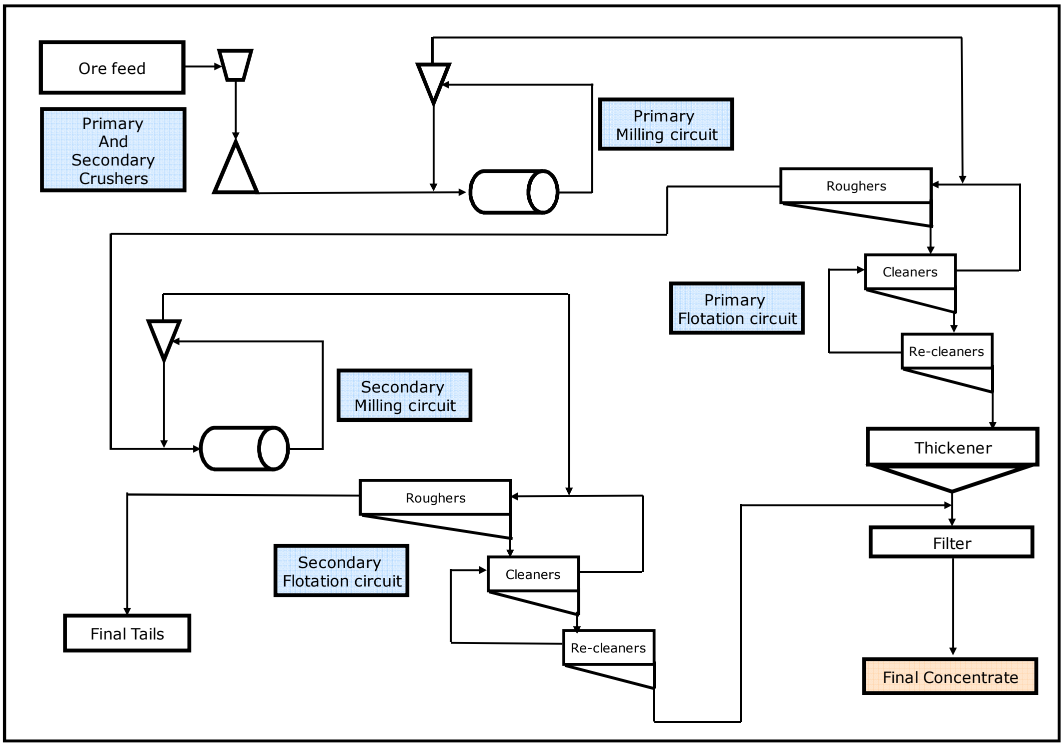


Figure 7.3.2 Simplified concentrator flow diagram

Crushing: Run of mine ore is crushed using jaw and gyratory crushers to reduce average material size to suit the grinding process.

Grinding: Crusher ore is reduced to a suitable size distribution for floatation through the use of rod, ball, semi-autogenous or autogenous mills in conjunction with high pressure grind rollers (HPGR) and ultra fine grinding (IsaMilling).

Floatation: Suitably sized material from the grinding circuits is pumped into floatation cells and mixed with chemicals that bind to the PGM particles, rendering them hydrophobic. The solution is aerated and the PGM particles are carried to surface, where they are skimmed off. This PGM-rich base metal sulphide concentrate material is termed concentrate and the residual material, tailings.

In cases where the smelter plant is located nearby and transport costs are low, concentrate is sent to the smelter in a slurry form with grades of 80-170 g/t. Where transport is necessary, concentrate is upgraded by repeating the floatation process, thereby increasing grades (and operating costs) to approximately 400 g/t, and reducing volumes, which are further reduced by pressing the concentrate into a filter cake form to remove excess moisture.

Retreatment: Concentrate is transported to the smelter for further processing whilst tailings are deposited in on-site tailings dams. Depending on the PGM grade of tailings materials it may be reprocessed (or stockpiled for reprocessing). UG2 tailings are normally further processed to recover chromite as a further by-product prior to deposition in the tailings dam or reprocessing for further PGM recovery.

Dense Media Separation (DMS): Although not standard industry practice, a DMS loop is often included in a UG2 concentrator plant, between the crusher and the mills. The DMS removes the waste material in the crushing circuit, effectively increasing the grade of the ore for grinding. This increases overall plant throughput but has varying impact on overall recovery depending on the mineralogy of the orebody.

7.3.2 Smelting

The smelting activity involves three basic steps; drying, smelting and converting. Typically concentrate is dried and fed to a melting furnace in which the gangue minerals separate to form a furnace slag and the valuable metals form a furnace matte containing typically 40% iron, 20% nickel, 10% copper and 30% sulphur as its major components. The furnace slag is granulated and removed from the smelter circuit. The furnace matte is transferred to converters in which the sulphur content is reduced by blowing oxygen or air through the molten matte. The iron is oxidised and combined with silica added as a flux to form converter slag. The final converter matte is either cast into moulds or granulated. The converter matte typically contains around 50% nickel, 28% copper and about 21% sulphur with the balance being made up of iron, cobalt, minor elements and PGMs at concentrations of around 2 000 to 5 000 g/t.

Converter slag can be returned to the melting furnace, discarded with the granulated smelter slag or re-treated in a slag cleaning furnace to recover entrained base metals and PGMs before being discarded with the slag. The final discard slag steam is either transported to a discard slag dump or fed to a slag retreatment plant to recover entrained metals by milling and floatation. The concentrate from the slag treatment plant is returned to the smelter feed stream and the tailings discarded to a disposal facility.

Particulate matter in the off gases from furnaces and converters is collected in precipitators and returned to the melting furnaces, before the gases are treated in a sulphur recovery plant, usually to produce sulphuric acid. A typical smelter flow diagram is indicated in Figure 7.3.3.

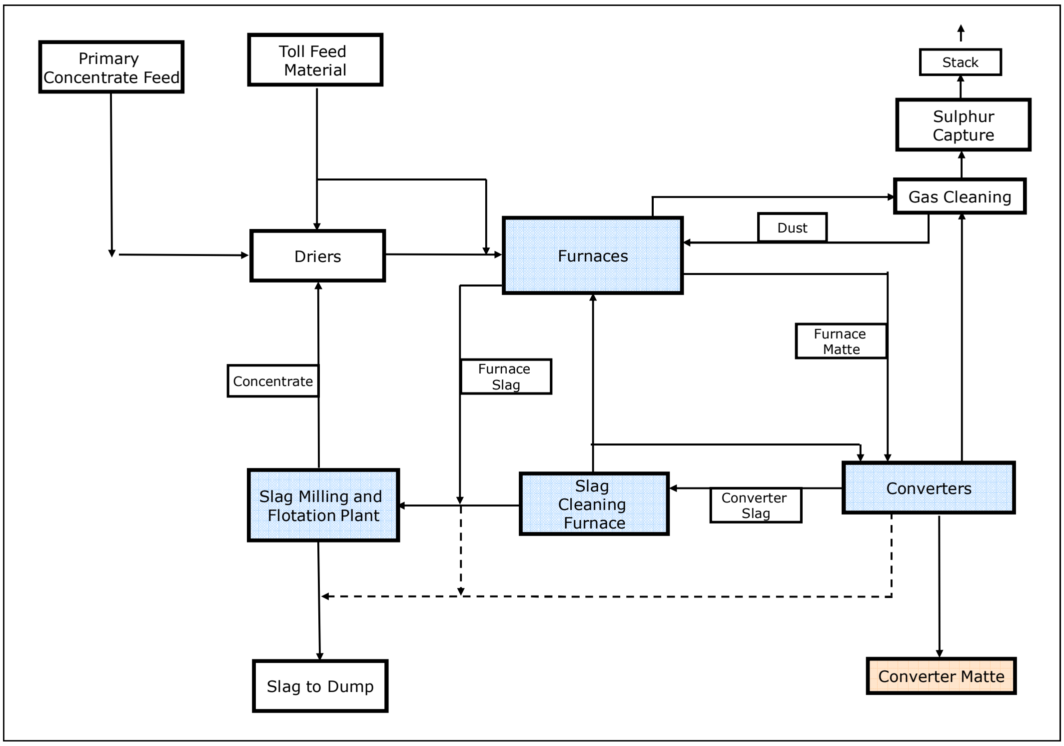


Figure 7.3.3 Typical PGM producer smelter flow diagram

Drying: Concentrate is first dried to reduce the moisture levels to below 0.5%. This is necessary because excessive moisture, once heated in the furnace, would increase the pressure of the furnace beyond design limits.

Smelting (furnace): Concentrate is then heated in the furnace to approximately 1 500℃. The molten concentrate separates into precious and base metal bearing matte and slag (silica, sulphur and iron). The denser matte is tapped on one side of the furnace while the slag is tapped on the opposite side. The tapped matte is approximately 1 300℃ and the PGM grade ranges between 1 000 and 1 500 g/t.

Converting: The primary purpose of the converter is to remove iron from the matte. This is achieved by blowing oxygen through the matte, which oxidizes the iron and creates a slag on the surface that is then skimmed off. The resulting matte, termed converter matte, has a PGM grade of approximately 5 000 g/t.

7.3.3 Base and precious metal refining

Metallurgical concentration activities to this point in the value chain have been physical (crushing, grinding and floating) and pyrometallurgical (smelting and converting). Refining however comprises hydrometallurgical processes in two key areas; base metals and precious metals recovery.

Base metal refining

The base metal refinery (BMR) provides an upgrading step in the preparation of a PGM rich concentrate suitable for input to the precious metal refinery. Flow sheets do vary from operation to operation dependent on the form of matte and base metal products that are treated, with a simplified generic flow sheet indicated in Figure 7.3.4. Essentially converter matte is processed through the BMR where base metals (nickel, copper and cobalt) are chemically removed.

In general, smelter converter matte is milled prior to leaching to recover the bulk of the nickel and copper. The residue remaining after the secondary copper leach undergoes a tertiary leaching phase to upgrade a final PGM concentrate for transfer to the precious metal refinery.

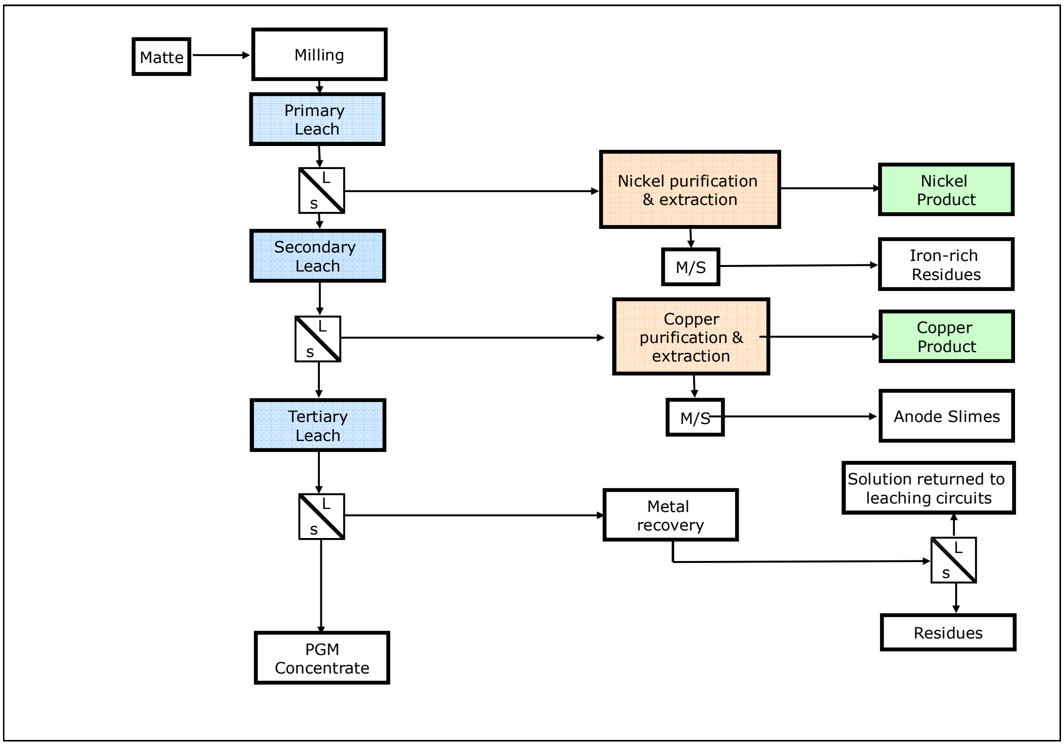


Figure 7.3.4 Base metal refinery block flow diagram

Precious metal refining

Similarly precious metal refinery flow sheets differ from one operation to another dependent on the specific technology applied. Essentially PGMs and precious metals are removed in a predefined sequence using ion-exchange, solvent extraction, electrolysis, crystallisation and/or distillation. Once removed, the metals are refined through an optimised closed-circuit loop that differs for each metal. The refining time also varies for each metal and can lock-up metal, in the process, for as long as three months.

Figure 7.3.5 shows a simple, generic block flow diagram for a typical precious metal refinery. All refining stages operate under negative pressure environments with the extracted gasses from the various processes and stages being scrubbed before release to the atmosphere. Scrubbing liquors are further treated to extract any trace amounts of PGMs.

The individual PGMs are produced in a variety of physical forms depending on customer and end use specifications – granules, ingot, plate, powder and sponge (calcinations of a metal chemical compound).

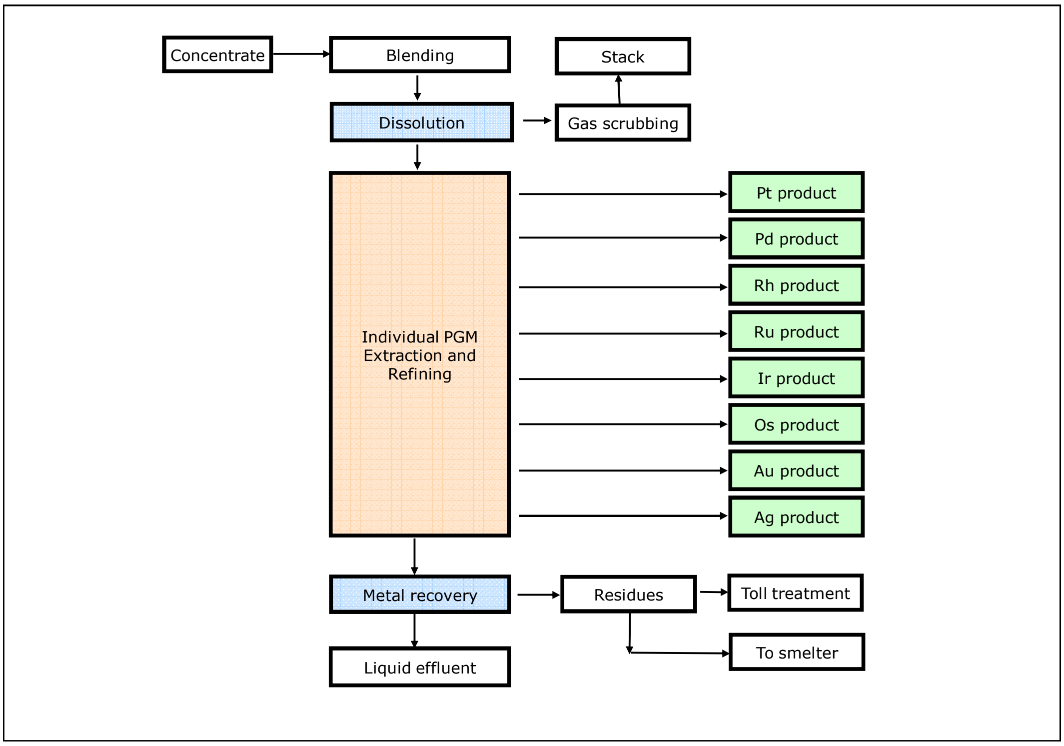


Figure 7.3.5 Precious metal refinery block flow diagram

7.4 Fabrication and end use

The three main PGMs, platinum, palladium and rhodium, are used primarily as catalytic converters in emission control equipment. However, they also have other important specialised applications in the high technology, electrical, chemical and petroleum refining industries. These include uses in fertiliser and glass manufacturing, in dental alloys and in fuel cells. Platinum, and to a lesser extent palladium, is also much in demand for jewellery and as bars and coins for investment purposes.

The PGM value chain is highly concentrated with five integrated suppliers (mining companies) providing most of the global supply of refined PGMs to a limited number of key intermediaries who service a broad spectrum of end users (see Figure 7.4.1). Significant interdependency exists between industry participants, with the security of supply key for sustainable industry development.

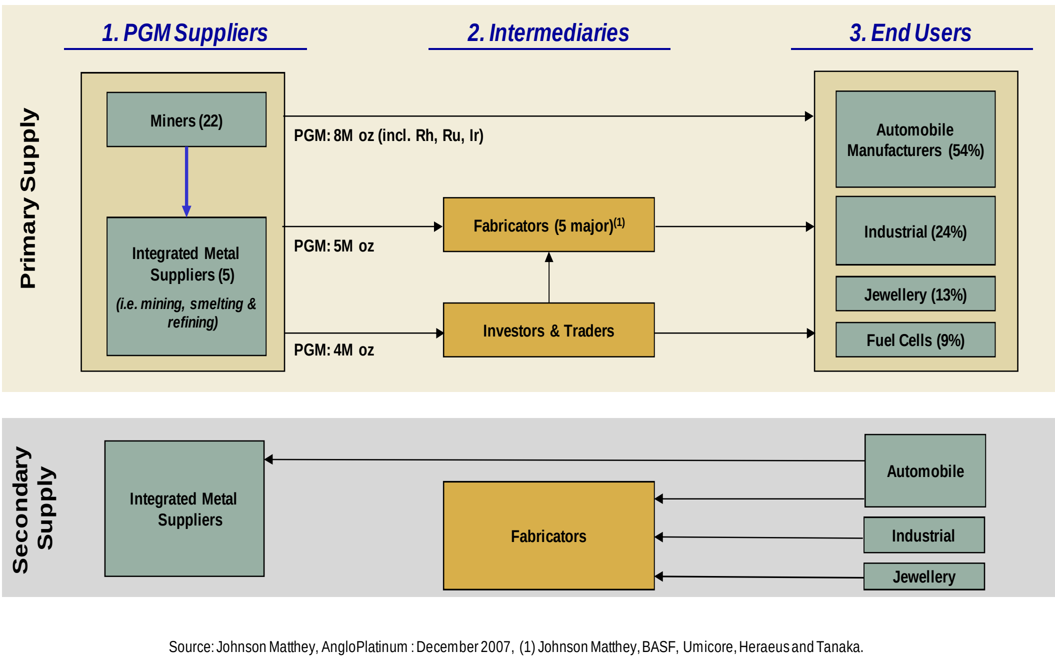


Figure 7.4.1 Platinum industry – structure and concentration (after Anglo Platinum Limited, Industry and Competitor Analysis 2007)

7.4.1 Integrated mining companies

The predominant producers are vertically integrated Southern African mining companies, typically:

- The primary PGM producers consider platinum as the main product;
- They are vertically integrated pure metal suppliers – from mineral resource to metal product;
- They are focused on long-term market sustainability to match long term mineral assets;
- A high volume of production is regionalised to South Africa;
- Long term mineral right tenure is a key success factor;
- Pt and Pd are priced to market with negligible discounts; and
- Mineral rights access could change industry structure causing supply fragmentation and influencing market dynamics.

Secondary producers of consequence are:

- Primary base metal producers, PGMs are by-products of nickel and / or copper production; and
- Their strategic objective is to maximise value from PGMs (especially palladium) – through controlled release of metal to market.

7.4.2 Fabricators

Characteristics of and influences on fabricators include:

- Investment in R&D and own intellectual property (IP);
- Provision of technical solutions to users based on market need and technological innovation;
- Require access to metal – they hold strategic stockpiles but are not vertically integrated;
- Some low-margin metal distribution is done to stimulate R&D;
- The majority of metal is accessed through direct sales agreements with primary producers; and
- Market growth in India and China could encourage the entry of new participants in these markets; however access to IP and cost of capital would be a barrier.

7.4.3 Investors/traders

The investors and traders in the industry typically:

- Provide market liquidity and price discovery through open market transactions;
- Offer opportunity to hedge price risks;
- Favour price volatility – this creates arbitrage opportunity; and

- Can have a significant influence on short term market prices through speculative transactions.

7.4.4 Auto manufacturers and industrial users

Influences on auto manufacturers and industrial users include:

- Driven by legislation and technical performance of PGMs offering the best solution to technological demand;
- They have concerns over the security of supply – large, long term business;
- PGMs are a small percentage of final product cost but highly strategic e.g. catalyst and gauzes;
- Constant search for cheaper substitutes to drive business efficiency; and
- The motor vehicle industry is an important industry in the economy of countries, thus making PGMs of strategic importance to governments.

7.4.5 Jewellers

The jewellery industry is characterised and influenced by aspects of:

- Sensitivity to price volatility – there is a long lead time from metal purchase to jewellery piece sale – this heightens stockholding risk;
- Brand strength is key to sustainability and growth as PGMs are not traditional default precious metals;
- Require constant market development support to sustain demand;
- Buy the marginal ounce and hence provide price tension in the market; and
- China's market structure and characteristics support potential growth.

7.5 Contribution to the Conceptual Framework

Insight into the nature of the value chain is crucial for business success in any industry. This understanding must be acquired at a fundamental structure or composition level but critically, deeper understanding is required of the financial value associated with each element of the value chain to allow business optimisation.

Key aspects are:

- The PGM value chain is highly concentrated with five integrated suppliers (mining companies) providing most of the global supply of refined PGMs to a limited number of key intermediaries who service a broad spectrum of end users.

Significant interdependency exists between industry participants, with the security of supply key for sustainable industry development;

- The major industry producers tend to be integrated along the value chain and as such have considerable assets in the mining and processing value chain elements. This is a barrier to entry to new participants;

- Owing to the nature of the mineral resource, underground mining of hard rock, narrow tabular, deposits predominates. This drives high capital intensity for access infrastructure development and long lead times to production;

- Within the value chain the greatest opportunity to vary production of metals and the metal mix, lies in the mining activity, owing to the greater number of sources of metal; and

- The bulk (~70%) of operating profit arises from mining and processing activities rather than from application and retail.

This understanding of the value chain and the relative contribution of each element and the participants is an integral part of value based management which is articulated in Section 11.6, as a critical component of the strategic long term planning conceptual framework.

8 CHARACTERISTICS OF THE PGM MARKET

The objective of this chapter is to provide broad understanding of the PGM market, which is a crucial part of the Strategic Long Term Planning Framework as schematically indicated in part A of Figure 3.1.

Understanding of the market and the participants informs value based decisions and influences strategic action. This is the critical logic embedded in Porters "five forces" analysis (Porter, 1980) as widely applied and covered in Section 8.4.

The information in this section has been summarised using statistics and information largely sourced from Johnson Matthey research publications on PGM metal supply and demand (2000 to 2010).

8.1 Applications of PGMs

8.1.1 Autocatalysis

Automotive catalytic converters were first developed in the 1970s and were initially fitted to petrol (gasoline) fuelled cars in North America from 1975 in order to reduce their emissions of pollutants. The first catalysts used a simple formulation of platinum deposited on aluminium oxide which in turn was coated onto a support material so that it could be placed in the exhaust stream of the vehicle. These designs were essentially two-way oxidation catalysts, which have evolved into the now commonplace three-way catalysts (for petrol vehicles). Palladium analogues of these platinum catalysts were later developed and have since become the dominant technology on light duty petrol vehicles. Volkswagen, in 1989, was the first company to fit platinum-based diesel oxidation catalysts (DOC) to its diesel cars. In 1993, emissions rules were applied to new diesel passenger cars sold in the European Union and these catalysts began to be fitted as standard on new vehicles. Platinum has historically been favoured for use in diesel after-treatment because the exhaust stream of a diesel engine is a highly oxidising environment and, under these conditions, palladium is readily converted to the less catalytically-active palladium oxide, whereas platinum remains in its metallic form. Palladium has however made inroads into the light duty diesel sector in diesel particulate filters (DPFs). A typical oxidation catalyst formulation currently in use might have a platinum to palladium ratio of 2:1 in weight terms (or about 1.2:1 in atomic terms). The launch of catalysts containing equal amounts of platinum and palladium seems now to be inevitable and further development beyond this ratio may be possible in some cases, although it may not prove possible to apply such technology universally. With the global market for diesel vehicles expected to expand over the medium term, good prospects exist for enhanced demand for both metals.

Euro VI emission legislation will be implemented from 2014. The legislation promulgates a decrease of more than 50% in allowable emissions of NO_x. It is expected that most large diesel vehicles will be fitted with selective catalytic converter systems employing only small amounts of platinum group metals (PGMs) in ammonia slip catalysts. However, these systems require special tanks for urea that add both volume and weight to a vehicle, making them unsuitable for small diesel vehicles. It is anticipated that a proportion of small diesel vehicles may meet the NO_x limits through engine adjustments, while the remainder will be fitted with NO_x adsorber traps containing PGMs.

The Japanese government introduced an eco-car subsidy programme in the middle of 2009. Cash incentives were offered to people who scrapped and replaced their vehicles with more fuel-efficient models. OEMs hastened to develop and offer vehicles meeting these criteria, for instance hybrids, plug-in hybrids and electric vehicles. The Democratic Party of Japan has set a greenhouse gas reduction target for 2020, while the prime minister has proposed a 25% reduction in greenhouse gases from 1990 levels by that year. In order to attain these levels, OEMs will have to provide more hybrid and non-conventional technologies. Conventional petrol and diesel vehicles are expected to account for ~67% of all vehicles in 2015, compared with ~90% at present. Hybrid technology will require PGM-based exhaust after-treatment and does not therefore present a threat to the market. Fuel-cell vehicles are set to play an important role in achieving reductions in CO_2 in the long term. Once plug-in hybrid vehicles enter the market, Japan will be in the unique position of having every motor vehicle propulsion technology, including fuel-cell vehicles, on its roads.

As details of the new legislation for US vehicle greenhouse gas (GHG) emissions and corporate average fuel economy standards became available, North American vehicle manufacturers continue to adjust power train portfolios to meet the requirements for 2012 to 2016. Engine downsizing and turbo charging, hybridisation, an increased number of speeds for both automatic and manual transmissions, mass reduction, drag reduction and alternative fuels are among the key measures through which manufacturers are seeking to reduce fuel consumption in their vehicles. Although a reduction in average engine size may reduce the PGM loadings required on exhaust after-treatment, the hybridisation of vehicles presents no threat to PGM technology. In the US, as in other regions of the world, the implementation of regulations seeking to reduce emissions of greenhouse gases offers an opportunity for diesel and fuel-cell technologies. The Environmental

Protection Agency and the Department of Transportation in the US are coordinating their efforts to propose standards for fuel economy and for the control of GHG emissions.

China is the leading vehicle market in the world. Euro IV-equivalent emission legislation is in place in the major cities of Beijing, Guangzhou and Shanghai, while Euro III-equivalent legislation applies in the rest of the country. Euro IV is scheduled for nationwide implementation in 2010, followed by Euro V in around 2012. As most of the vehicles built in China are petrol driven (with diesel accounting for less than 15% of light-duty vehicle production), the increase in vehicle production has resulted in a greater increase in demand for palladium than for platinum (Anglo Platinum, 2009).

8.1.2 Jewellery

In the international jewellery industry, platinum's strength and tarnish-resistant qualities have increased its popularity in markets that have traditionally been dominated by gold. The ability of platinum to be repeatedly heated and cooled without hardening and oxidation effects, as well as its ability to produce settings which permanently retain their shape, has made the metal popular among jewellery manufacturers, although the use of platinum does make certain demands on the skills of the jeweller.

Platinum is widely used in jewellery and extensively promoted by jewellery bodies. Platinum jewellery has become highly desirous for wedding ceremonies, especially in China. However, non-bridal platinum jewellery continues to attract new buyers.

Up until 2004 the use of palladium in jewellery was limited to alloying with gold to produce white gold. Palladium jewellery was introduced in China in 2004. Not only did it offer the retailer larger margins than platinum, but it also helped manufacturers to use up idle capacity when demand for platinum was low. However manufacturers are reporting declining interest in palladium jewellery.

The year 2009 was exceptional for platinum jewellery in China with gross demand rising from 1.06 million ounces to a record 2.08 million ounces. In the most general terms, this was due to the twin stimuli of a lower platinum price and a booming domestic economy. The real picture is rather more complex, with the motivations of consumers, manufacturers, retailers and wholesalers all playing their part. Imports of fine, lightweight platinum chain from Japan also benefited, helping to increase Japanese platinum jewellery manufacturing demand.

The narrowing price differential between gold and platinum also aided platinum demand. With the gold price stronger in 2009 than in 2008 and the platinum price weaker, the differential in price between the two metals shrank. Although the gold jewellery market remains much larger than the platinum market, this made platinum relatively more attractive to some consumers, with demand for platinum improving accordingly. During 2007 and 2008, an increasing amount of white gold could be seen as retailers tried to maintain sales in the face of rising prices for platinum and for diamonds. However, white gold has a lower brand acceptance than platinum within China. Thus, when the platinum price fell, retailers gladly returned to stocking more platinum at the expense of white gold. Consumers happily bought platinum at these more affordable prices instead of being forced to trade down to the cheaper white gold (Johnson Matthey, 2010).

While lower platinum prices have clearly benefited affordability and platinum demand, the longer term impact of price changes and price volatility on consumer perception of platinum is more complex. Precious metal jewellery in China is both an adornment and an investment. Although a rising price hurts affordability, it may make a material more attractive as an investment. For some consumers, the rising price of platinum in 2009 was therefore a positive factor, encouraging purchasing. For others, the precipitous fall in the price of platinum of late 2008 may have damaged confidence in its future value. The balance between these two opposing trends is hard to ascertain but demonstrates the complexity of consumer thinking in this market.

Although the underlying health of the Chinese platinum jewellery sector remains fairly good, it is unrealistic to expect the demand levels of 2009 to be sustained in the future. The factors leading to the heavy stock-building of 2009 are unlikely to be repeated. Higher bullion prices started to impact upon the affordability of platinum jewellery and there were some signs of inventory reductions in the first part of 2010.

8.1.3 Industrial applications

The electronic and electrical sectors

Platinum and ruthenium are utilised in the manufacture of hard-disk drives however reduced amounts of platinum are being used on the disks owing to design and manufacturing efficiency improvements. Furthermore, solid-state devices (SSDs) or flash memory are replacing hard-disk drives in certain applications. SSDs are expected to infiltrate many smaller applications. However, it is anticipated that the demand for hard-disk drives will continue to grow in the larger segments.

Platinum is also utilised in thermocouples used in the manufacture of steel, glass and semiconductors.

The largest area of palladium consumption in the electronic sector is in multi-layer ceramic capacitors (MLCC), which feature a palladium/silver conductive electrode material layered between insulating ceramic wafers. However nickel-based MLCC production has grown and now accounts for ~80% of total output. The growth in this substitution has slowed, however, as the financial disincentive posed by extremely high palladium prices has dissipated. Furthermore, palladium's physical properties mean that palladium based MLCC are still preferred for use in engine management systems in vehicles and in exacting environments such as aerospace.

Palladium is used with silver to connect electronic components in hybrid integrated circuits. Palladium is also used to plate connectors that link components in electronic circuitry. Although gold can also be used in this application, palladium has a lower density than gold and thus less metal is required. Integrated circuits are connected to other electronic devices using lead frames. Some manufacturers use palladium to plate the frames, as an environmentally preferable alternative to tin-lead solder. Gold can also be used in place of palladium, but a price advantage of palladium over gold would encourage a move towards palladium.

The chemical sector

Platinum catalysts are used in many chemical processes, including the production of nitric acid, silicones and paraxylene. The use of platinum catalysts to produce nitric acid is one of the metal's oldest industrial applications. In the manufacture of nitric acid ammonia gas is oxidised over a platinum-rhodium catalyst to produce nitric oxide, and is further oxidised to form nitrogen dioxide. The nitric dioxide is then added to water to form nitric acid. Some of the precious metals are lost in the process, but palladium catchment gauze can be used to reduce the losses. As the demand for fertilisers declined globally in 2008 and 2009, nitric acid plants operated at very low capacity, decreasing the demand for platinum. Further reducing the demand for new metal was the fact that manufacturers used metal from mothballed burners to supplement metal lost in operating burners. The single largest consumer of platinum in the chemical sector is silicones as the platinum is consumed in their production and cannot be recovered.

Palladium is employed primarily in process catalysts used to produce plastic intermediates such as purified terephthalic acid (PTA) whilst ruthenium is used in the production of chlorine.

Glass

Equipment used in the glass industry is made from platinum alloys on account of platinum's high melting temperature, strength and corrosion resistance. Platinum is used in the manufacture of liquid crystal displays (LCDs), cathode ray tube (CRT) displays and optical glass, while platinum/rhodium bushings are used to manufacture glass fibre. Demand for speciality glass has benefited in the recent past from improving sales of personal computers and LCD televisions. The return of metal from the closure of fibre glass and CRT facilities has sent significant amounts of metal back to the market. The recent construction of new LCD tanks may be insufficient to make up for this loss of demand. The decline in rhodium demand was buffered to some extent by a return to alloys containing a higher proportion of rhodium. Alloys with a higher rhodium content offer increased durability.

Petroleum refining

Platinum catalysts are used in the reforming and isomerisation steps in the refining of petroleum. As process losses are small, significant increases in demand occur only when capacity expansions are undertaken. With the demand for petroleum based fuels declining as the global economy slowed in 2009, the lifetime of catalysts was extended, reducing top-up demand. However legislation requiring increased production of renewable fuels is driving the development of biofuel facilities which is likely to result in increased capacity requirements. The European Union's directive is that 5.75% of transport fuel should come from renewable resources by 2010. Some of the processes in the production of renewable fuels require platinum catalysts, and the future construction of refineries in this sector will buoy demand for platinum.

Dental alloys

Palladium and, to a lesser extent, platinum are alloyed with other metals for use in dental restorations such as crowns. High-gold alloys usually contain platinum while low-gold alloys contain 50% to 80% palladium. In Japan the government specifies the alloy used for subsidised dental work. Known as Kinpala alloy, it contains 20% palladium. Japan is the leading market for palladium dental alloys, with consumption of about 240 koz per year. Palladium demand decreased in North America, despite a positive price differential between gold and palladium.

Other industrial applications

Other applications requiring platinum, although individually small, together consume a significant amount of the metal each year. Key automotive applications are the use of platinum in oxygen sensors, spark plugs and turbine blades. Platinum also plays an important role in medical applications, including pacemaker electrodes and guide wires with coiled platinum tips able to locate blockages in arterial disease. Demand for internal cardioverter defibrillators continues to buoy demand for platinum in biomedical devices.

The production of anti-cancer drugs, for example cisplatin, carboplatin and oxaliplatin, underpins increasing demand in cancer treatment around the world.

Non-road engines

Although at present non-road vehicles account for only a small quantity of PGMs, the introduction of legislation over the next few years will see expanding demand from this sector. More exacting standards requiring reductions in particulate matter and NO_x will require after-treatment. In Europe this will occur from 2011, when Stage IIIB legislation is implemented. In the US, emission legislation is harmonised to some extent with that of Europe and Tier 4 emission standards are being phased in from 2008 to 2015. In Japan, where present legislation does not require exhaust after-treatment, the Ministry of Energy is currently considering more exacting standards for non-road vehicles. As Japan is a large exporter of non-road vehicles, original equipment manufacturers (OEMs) will be fitting diesel oxidation catalysts (DOCs) and diesel particulate filter (DPF) systems in order to meet legislation in Europe and the US.

Fuel cells

Fuel cells are electro-chemical generators of electricity, the electricity being produced by a reaction between hydrogen and oxygen, with platinum as a catalyst. As there is no combustion of carbon fuel, there are no noxious emissions. The only by-products of the process are heat and water. Although the concept of fuel cells has long been understood, it is only recently that their commercial use has been explored. The primary driver behind research into fuel cells has been the increasingly severe emission controls promulgated worldwide.

There are different types of fuel cells: alkaline fuel cells (AFCs), which have provided power on spacecrafts; direct methanol fuel cells (DMFCs); molten carbonate fuel cells (MCFCs); solid oxide fuel cells (SOFCs); and proton exchange membrane fuel cells (PEMFCs). These all have specific properties that lend themselves to different applications. However, the PEMFCs, which contain platinum, are the most versatile and can be used to power anything from the smallest electronic device through to vehicles. The PEMFC is seen as the best option in developing an emissions-free vehicle that runs on hydrogen. A number of issues remain to be resolved prior to the commercialisation of fuel-cell vehicles; however vehicle manufacturers are launching hybrid vehicles (some with fuel cells) in the intervening years. One of the first commercial markets for fuel-cell technology will be the portable power sector, for which products are currently being developed. Demand for larger, portable fuel-cell systems, particularly by the military, is strong: such systems have greater power density and are capable of running longer than conventional batteries, and are also easier to recharge. The small (under 10 kW) stationary market grew strongly during 2009 with consumer demand for uninterruptible power supplies increasing owing to concerns over sustainable energy supply. PEMFCs are expected to remain the dominant technology in the residential sector, which is a positive development in terms of platinum consumption.

8.1.4 Investment

Exchange-traded funds (ETFs) are designed to enable investment in specific commodities without the investor having to take physical delivery of the product. These funds are backed by physical metal and as such are considered part of investment demand. There were no ETFs for trading in PGMs prior to 2007, but since their introduction in April 2007, ETFs for platinum group metals are now traded on the London, New York and Swiss exchanges. ETFs in platinum and palladium posted gains in 2009: the combined holdings totalled 678 759 ounces and 1.167 million ounces respectively at year end. Interest in coins has also increased, particularly in North America. In Japan investors began purchasing small platinum bars towards the end of 2008, and this activity continued into the first part of 2009. The Royal Canadian Mint produces both platinum and palladium coins, and the Australian and US mints produce platinum coins for investment purposes.

8.2 Demand and pricing

Historic supply and demand data and commentary in this section has been sourced from Johnson Matthey annual reports on the platinum market. The objective of the section is to provide context and historical awareness of market dynamics and variability, and not specific analysis of the supply/demand/price dynamic of the PGM industry.

PGMs are attractive or essential in a broad range of industry sectors, offering the most efficient, cost effective solution to technical challenges. Several physical and chemical characteristics of PGMs make them critical for commercial applications primarily:

- Low-temperature and durable catalytic activity;
- High melting point / ductility; and
- Resistance to oxidation.

Global demand for platinum, palladium and rhodium has been generally strong over the past 15 years depending on application. However the nature of application and associated demand for the metals has shifted in recent years. The demand for PGMs has been largely driven from four sectors:

- The automotive industry, primarily autocatalysis;
- Industrial applications (chemicals, electronics, glass, petroleum, medical/dental etc.);
- Jewellery; and
- Investment purposes.

Commentary has been made on the specific applications of PGMs in these sectors (see Section 8.1) and will not be further covered. Emphasis here is placed on the nature of demand.

Demand characterisation

The demand for PGMs can be broadly characterised into two groupings; derived demand and created demand.

Derived demand is where the demand for metal is derived from an underlying product downstream of the commodity and the metal is a small proportion of the end use product. Derived demand arises principally from PGMs' physical and chemical characteristics, such as in catalytic converters in the automotive industry or for fuel reforming in the petroleum industry. Derived demand arises in the automotive and industrial demand sectors. Derived demand for PGMs is typically positively correlated with price.

Created demand is where demand is created for the metal itself through marketing activities. In created demand the proportion of metal in end product is high. Created demand is largely generated by jewellery for aesthetics or by investment funds for wealth retention. Created demand for PGM is typically negatively correlated with price, providing a measure of protection against sustained, excessively high or low prices.

8.2.1 Platinum

Supply and demand for the period 2000 to 2009 is indicated in Tables 8.2.1 and 8.2.2

Table 8.2.1 Global platinum supply and demand (Johnson Matthey, 2010)

Platinum Supply and Demand										
'000 oz	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Supply										
South Africa	3 800	4 100	4 450	4 630	5 010	5 115	5 295	5 070	4 515	4 530
Russia	1 100	1 300	980	1 050	845	890	920	915	805	785
North America	285	360	390	295	385	365	345	325	325	260
Zimbabwe	-	-	-	-	-	155	165	170	180	230
Others	105	100	150	225	250	115	105	120	115	115
Total Supply	**5 290**	**5 860**	**5 970**	**6 200**	**6 490**	**6 640**	**6 830**	**6 600**	**5 940**	**5 920**
Demand by Application										
Autocatalyst	1 890	2 520	2 590	3 270	3 490	3 795	3 905	4 145	3 655	2 230
Chemical	295	290	325	320	325	325	395	420	400	295
Electrical	455	385	315	260	300	360	360	255	230	190
Glass	255	290	235	210	290	360	405	470	315	10
Investment	-60	90	80	15	45	15	-40	170	555	660
Jewellery*	2 830	2 590	2 820	2 510	2 160	2 465	2 195	2 110	2 060	3 010
Medical & Biomedical	-	-	-	-	-	250	250	230	245	250
Petroleum	110	130	130	120	150	170	180	205	240	205
Other	375	465	540	470	470	225	240	265	290	190
Total Gross Demand	**6 150**	**6 760**	**7 035**	**7 175**	**7 230**	**7 965**	**7 890**	**8 270**	**7 990**	**7 040**
Recycling										
Autocatalyst	-470	-530	-565	-645	-690	-770	-860	-935	-1 130	-830
Electrical	-	-	-	-	-	0	0	0	-5	-10
Jewellery	-	-	-	-	-	-500	-555	-655	-695	-565
Total Recycling	**-470**	**-530**	**-565**	**-645**	**-690**	**-1 270**	**-1 415**	**-1 590**	**-1 830**	**-1 405**
Total Net Demand	**5 680**	**6 230**	**6 470**	**6 530**	**6 540**	**6 695**	**6 475**	**6 680**	**6 160**	**5 635**
Movements in Stocks	**-390**	**-370**	**-500**	**-330**	**-50**	**-55**	**355**	**-80**	**-220**	**285**

** Before 2005 jewellery and electrical demand is net of recycling.*
*** Before 2005 Medical & Biomedical was included in "Other"*

A significant deficit of around 5% - 7% existed through to 2003, followed by the market being essentially in balance during 2004 and 2005 with a 5% surplus in 2006. The demand compound annual growth rate during the period 2000 to 2005 was 3.3%. Supply and demand were in balance in 2007 with a swing back to a 4% deficit in 2008. The year 2009 showed a 5% surplus on the back of demand levels similar to 2000 following the global financial crisis in 2008 and severe curtailment of global economic activity.

Table 8.2.3 further indicates prices and stock movements associated with the period 2005 to 2009. Analysis by region and demand sector (Table 8.2.4) shows the strength of the growth in demand from China during the global economic crisis and the flexibility of the created jewellery demand to absorb significant amounts of metal following the drop off of autocatalysis and industrial demand during the crisis.

Table 8.2.2 Gross platinum demand by application and region (Johnson Matthey, 2010)

Gross Platinum Demand by Application: Regions

'000 oz	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Europe										
Autocatalyst	680	1 060	1 210	1 455	1 680	1 960	2 060	2 055	1 970	970
Chemical	100	105	115	105	115	100	100	110	105	70
Electrical	80	65	40	35	40	40	25	15	20	20
Glass	20	10	10	10	5	10	10	15	-25	5
Investment	0	0	0	0	0	0	0	195	105	385
Jewellery	190	170	160	190	195	195	200	200	205	185
Medical & Biomedical**	0	0	0	0	0	110	110	110	115	115
Petroleum	15	15	15	15	15	15	20	25	30	25
Other	105	155	190	185	190	65	65	75	85	55
Totals	**1 190**	**1 580**	**1 740**	**1 995**	**2 240**	**2 495**	**2 590**	**2 800**	**2 610**	**1 830**
Japan										
Autocatalyst	290	340	430	500	615	600	605	610	610	395
Chemical	20	25	30	40	40	50	50	55	55	45
Electrical	90	80	55	40	50	65	55	35	35	30
Glass	65	85	60	85	90	95	100	85	65	40
Investment	-95	45	40	-10	15	-15	-65	-60	385	160
Jewellery	1 060	750	780	660	560	670	585	540	530	535
Medical & Biomedical**	0	0	0	0	0	20	20	15	20	20
Petroleum	5	5	5	5	5	5	5	5	10	10
Other	35	35	55	40	40	25	20	30	25	15
Totals	**1 470**	**1 365**	**1 455**	**1 360**	**1 415**	**1 515**	**1 375**	**1 315**	**1 735**	**1 250**
North America										
Autocatalyst	620	795	570	885	800	820	705	850	505	370
Chemical	100	100	100	95	90	100	100	95	95	65
Electrical	145	120	100	85	90	95	75	55	30	25
Glass	50	35	30	-30	-10	5	10	25	-5	-35
Investment	35	45	40	25	25	25	20	30	60	105
Jewellery	380	280	310	310	290	285	270	225	200	135
Medical & Biomedical**	0	0	0	0	0	110	105	80	85	90
Petroleum	35	40	45	40	35	35	35	30	25	15
Other	210	250	265	215	205	110	120	135	150	90
Totals	**1 575**	**1 665**	**1 460**	**1 625**	**1 525**	**1 585**	**1 440**	**1 525**	**1 145**	**860**
China										
Autocatalyst	10	15	35	60	75	120	155	175	145	130
Chemical	20	10	10	10	10	10	65	70	60	40
Electrical	20	15	15	15	20	25	45	20	30	20
Glass	35	65	40	30	60	70	50	180	85	-90
Investment	0	0	0	0	0	0	5	0	0	0
Jewellery	1 100	1 300	1 480	1 200	1 010	1 205	1 060	1 070	1 060	2 080
Medical & Biomedical**	0	0	0	0	0	0	0	10	10	10
Petroleum	15	15	5	5	5	5	10	10	10	10
Other	5	5	5	5	5	10	10	5	10	10
Totals	**1 205**	**1 425**	**1 590**	**1 325**	**1 185**	**1 450**	**1 395**	**1 540**	**1 410**	**2 210**
Rest of the World										
Autocatalyst	290	310	345	370	320	295	380	455	425	365
Chemical	55	50	70	70	70	65	80	90	85	75
Electrical	120	105	105	85	100	135	160	130	115	95
Glass	85	95	95	115	145	180	235	165	195	90
Investment	0	0	0	0	5	0	5	5	5	10
Jewellery	100	90	90	150	105	110	80	75	65	75
Medical & Biomedical**	0	0	0	0	0	10	15	15	15	15
Petroleum	40	55	60	55	90	110	110	135	165	145
Other	20	20	25	25	30	15	25	20	20	20
Totals	**710**	**725**	**790**	**870**	**865**	**920**	**1 090**	**1 090**	**1 090**	**890**
Total Gross Demand	**6 150**	**6 760**	**7 035**	**7 175**	**7 230**	**7 965**	**7 890**	**8 270**	**7 990**	**7 040**

***** Before 2005 Medical & Biomedical was included in "Other"***

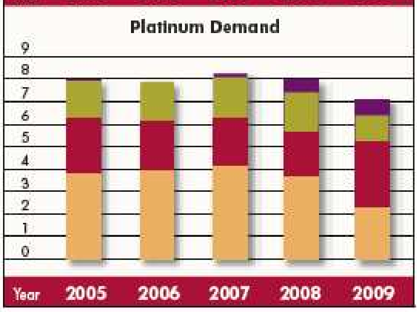
Table 8.2.3 Platinum – supply, demand and price 2005 to 2009 (Johnson Matthey, 2010)

Platinum Supply and Demand

	'000 oz	2005	2006	2007	2008	2009
Supply[1]	South Africa	5,115	5,295	5,070	4,515	4,530
	Russia[3]	890	920	915	805	785
	North America	365	345	325	325	260
	Zimbabwe[2]	155	165	170	180	230
	Others[2]	115	105	120	115	115
	Total Supply	**6,640**	**6,830**	**6,600**	**5,940**	**5,920**
Gross Demand by Application[4]	Autocatalyst[4]	3,795	3,905	4,145	3,655	2,230
	Chemical	325	395	420	400	295
	Electrical[4]	360	360	255	230	190
	Glass	360	405	470	315	10
	Investment	15	(40)	170	555	660
	Jewellery[4]	2,465	2,195	2,110	2,060	3,010
	Medical & Biomedical[5]	250	250	230	245	250
	Petroleum	170	180	205	240	205
	Other[5]	225	240	265	290	190
	Total Gross Demand	**7,965**	**7,890**	**8,270**	**7,990**	**7,040**
Recycling[6]	Autocatalyst	(770)	(860)	(935)	(1,130)	(830)
	Electrical	0	0	0	(5)	(10)
	Jewellery	(500)	(555)	(655)	(695)	(565)
	Total Recycling	**(1,270)**	**(1,415)**	**(1,590)**	**(1,830)**	**(1,405)**
	Total Net Demand[7]	**6,695**	**6,475**	**6,680**	**6,160**	**5,635**
	Movements in Stocks[8]	**(55)**	**355**	**(80)**	**(220)**	**285**

At a glance

million oz



Supply	Demand
Others	Investment
North America	Industrial
Russia	Jewellery
South Africa	Autocatalyst

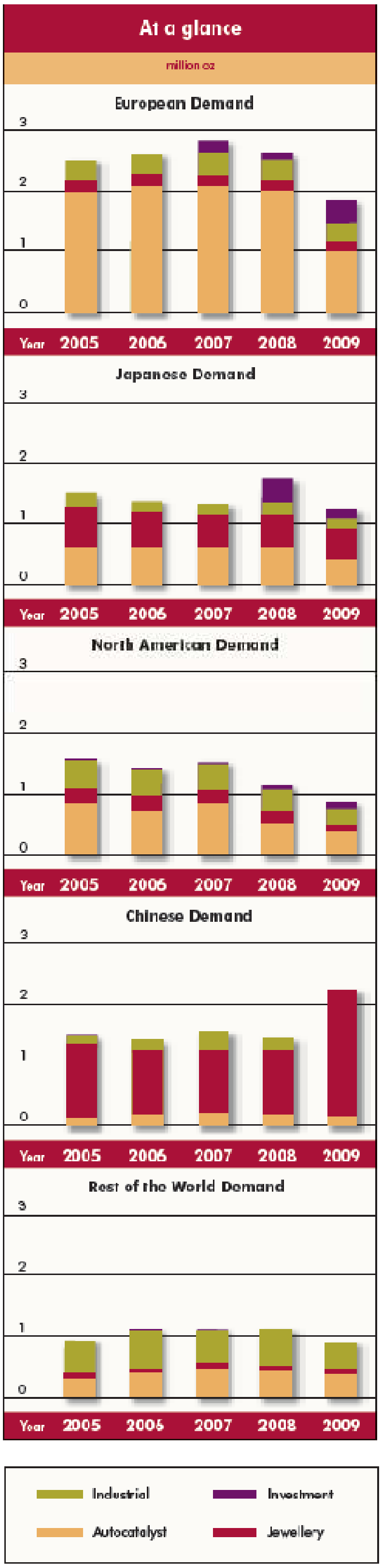
Average Price (US$ per oz)[9]

2005	2006	2007	2008	2009
897	1,143	1,304	1,576	1,205

Table 8.2.4 Platinum – supply and demand by application and region (Johnson Matthey, 2010)

Gross Platinum Demand by Region

Region	'000 oz	2005	2006	2007	2008	2009
Europe	Autocatalyst	1,960	2,060	2,055	1,970	970
	Chemical	100	100	110	105	70
	Electrical	40	25	15	20	20
	Glass	10	10	15	(25)	5
	Investment	0	0	195	105	335
	Jewellery	195	200	200	205	185
	Medical & Biomedical	110	110	110	115	115
	Petroleum	15	20	25	30	25
	Other	65	65	75	85	55
	Total	**2,495**	**2,590**	**2,800**	**2,610**	**1,830**
Japan	Autocatalyst	600	605	610	610	395
	Chemical	50	50	55	55	45
	Electrical	65	55	35	35	30
	Glass	95	100	85	65	40
	Investment	(15)	(65)	(60)	385	160
	Jewellery	670	585	540	530	535
	Medical & Biomedical	20	20	15	20	20
	Petroleum	5	5	5	10	10
	Other	25	20	30	25	15
	Total	**1,515**	**1,375**	**1,315**	**1,735**	**1,250**
North America	Autocatalyst	820	705	850	505	370
	Chemical	100	100	95	95	65
	Electrical	95	75	55	30	25
	Glass	5	10	25	(5)	(35)
	Investment	25	20	30	60	105
	Jewellery	285	270	225	200	135
	Medical & Biomedical	110	105	80	85	90
	Petroleum	35	35	30	25	15
	Other	110	120	135	150	90
	Total	**1,585**	**1,440**	**1,525**	**1,145**	**860**
China	Autocatalyst	120	155	175	145	130
	Chemical	10	65	70	60	40
	Electrical	25	45	20	30	20
	Glass	70	50	180	85	(90)
	Investment	5	0	0	0	0
	Jewellery	1,205	1,060	1,070	1,060	2,080
	Medical & Biomedical	0	0	10	10	10
	Petroleum	5	10	10	10	10
	Other	10	10	5	10	10
	Total	**1,450**	**1,395**	**1,540**	**1,410**	**2,210**
Rest of the World	Autocatalyst	295	380	455	425	365
	Chemical	65	80	90	85	75
	Electrical	135	160	130	115	95
	Glass	180	235	165	195	90
	Investment	0	5	5	5	10
	Jewellery	110	80	75	65	75
	Medical & Biomedical	10	15	15	15	15
	Petroleum	110	110	135	165	145
	Other	15	25	20	20	20
	Total	**920**	**1,090**	**1,090**	**1,090**	**890**
	Total Gross Demand	**7,965**	**7,890**	**8,270**	**7,990**	**7,040**



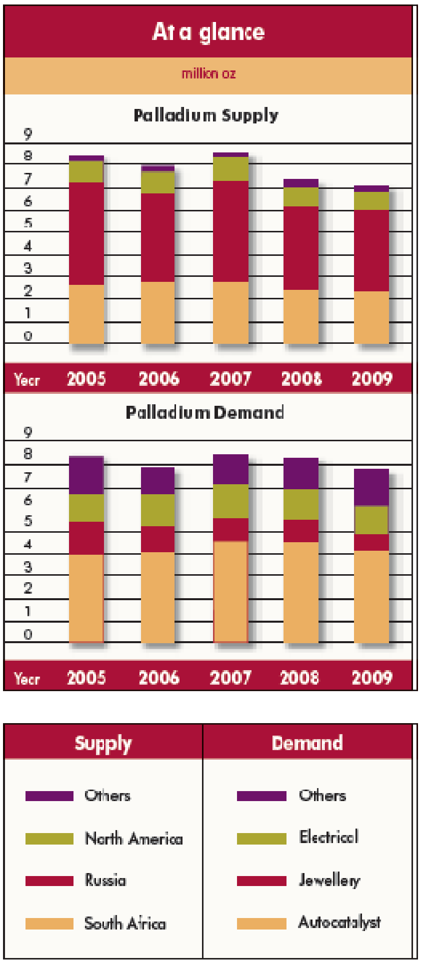
8.2.2 Palladium

Supplies of palladium have traditionally been significantly influenced by Russian stocks. However surpluses were significantly reduced in 2008 and 2009 following liberalisation of trading constraints. See Table 8.2.5.

Table 8.2.5 Palladium – supply, demand and price 2005 to 2009 (Johnson Matthey, 2010)

Palladium Supply and Demand

	'000 oz	2005	2006	2007	2008	2009
Supply[1]	South Africa	2,605	2,775	2,765	2,430	2,370
	Russia[3]					
	Primary	3,135	3,220	3,050	2,700	2,675
	Stock Sales	1,485	700	1,490	960	960
	North America	910	985	990	910	755
	Zimbabwe[2]	125	135	135	140	180
	Others[2]	145	135	150	170	160
	Total Supply	**8,405**	**7,950**	**8,580**	**7,310**	**7,100**
Gross Demand by Application[4]	Autocatalyst[4]	3,865	4,015	4,545	4,465	4,050
	Chemical	415	440	375	350	325
	Dental	815	620	630	625	615
	Electrical[4]	1,275	1,495	1,550	1,370	1,270
	Investment	220	50	260	420	625
	Jewellery[4]	1,490	1,140	950	985	815
	Other	265	85	85	75	70
	Total Gross Demand	**8,345**	**7,845**	**8,395**	**8,290**	**7,770**
Recycling[6]	Autocatalyst	(625)	(305)	(1,015)	(1,140)	(965)
	Electrical	(305)	(290)	(315)	(345)	(395)
	Jewellery	(60)	(135)	(235)	(130)	(70)
	Total Recycling	**(990)**	**(1,230)**	**(1,565)**	**(1,615)**	**(1,430)**
	Total Net Demand[7]	**7,355**	**6,615**	**6,830**	**6,675**	**6,340**
	Movements in Stocks[8]	**1,050**	**1,335**	**1,750**	**635**	**760**



Average Price (US$ per oz)[9]

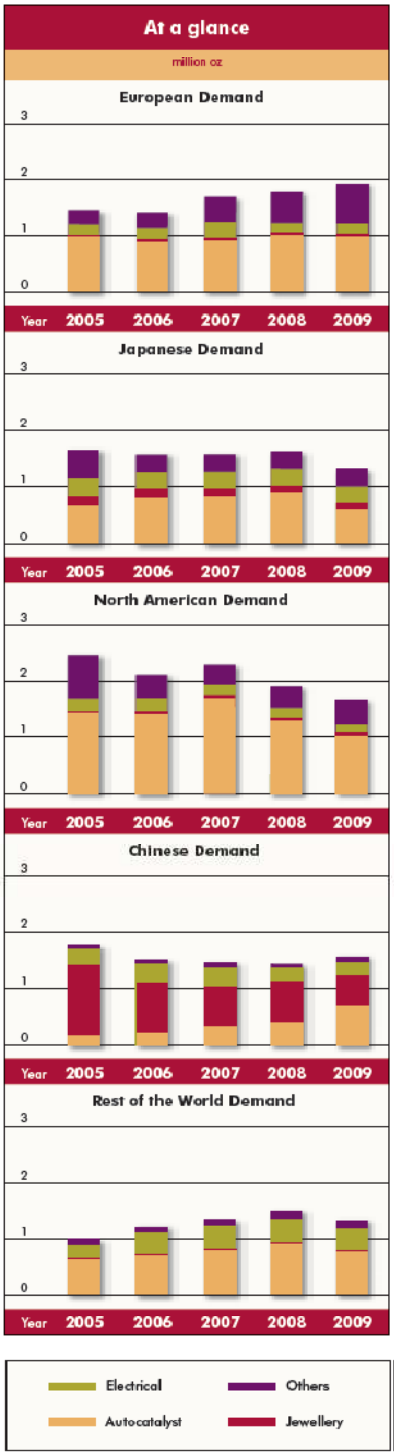
2005	2006	2007	2008	2009
201	320	355	352	264

Similar to platinum, resilience in demand by China was demonstrated during the global financial crisis. See Table 8.2.6.

Table 8.2.6 Palladium – supply and demand by application and region (Johnson Matthey, 2010)

Gross Palladium Demand by Region

Region	'000 oz	2005	2006	2007	2008	2009
Europe	Autocatalyst	975	890	920	1,005	995
	Chemical	155	175	95	100	85
	Dental	75	75	70	65	65
	Electrical	195	210	280	190	175
	Investment	0	0	280	370	525
	Jewellery	35	40	40	45	50
	Other	20	25	20	20	20
	Total	**1,455**	**1,415**	**1,705**	**1,795**	**1,915**
Japan	Autocatalyst	660	795	820	885	590
	Chemical	25	25	25	20	20
	Dental	475	270	275	275	275
	Electrical	325	330	325	320	305
	Investment	0	0	0	0	0
	Jewellery	155	145	125	115	120
	Other	10	10	10	10	10
	Total	**1,650**	**1,575**	**1,580**	**1,625**	**1,320**
North America	Autocatalyst	1,430	1,415	1,695	1,290	1,020
	Chemical	85	80	75	55	50
	Dental	250	260	265	270	260
	Electrical	245	240	195	170	155
	Investment	220	50	(20)	50	95
	Jewellery	20	40	55	60	60
	Other	215	30	30	20	15
	Total	**2,465**	**2,115**	**2,295**	**1,915**	**1,655**
China	Autocatalyst	170	220	325	390	685
	Chemical	55	65	80	55	75
	Dental	5	5	5	0	0
	Electrical	285	330	340	255	235
	Investment	0	0	0	0	0
	Jewellery	1,250	890	705	740	560
	Other	5	10	10	10	10
	Total	**1,770**	**1,520**	**1,465**	**1,450**	**1,565**
Rest of the World	Autocatalyst	630	695	785	895	760
	Chemical	95	95	100	120	95
	Dental	10	10	15	15	15
	Electrical	225	385	410	435	400
	Investment	0	0	0	0	5
	Jewellery	30	25	25	25	25
	Other	15	10	15	15	15
	Total	**1,005**	**1,220**	**1,350**	**1,505**	**1,315**
	Total Gross Demand	**8,345**	**7,845**	**8,395**	**8,290**	**7,770**



8.2.3 Rhodium

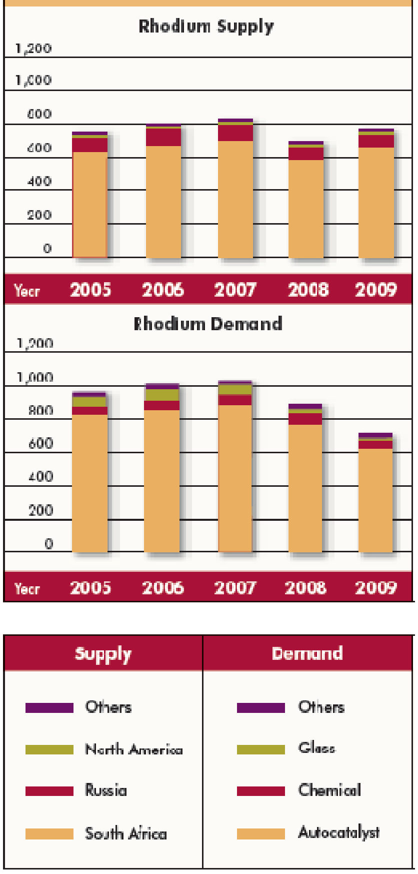
Rhodium supply, demand and pricing over the period 2005 to 2009 are indicated in Table 8.2.7.

Table 8.2.7 Rhodium – supply, demand and price 2005 to 2009 (Johnson Matthey, 2010)

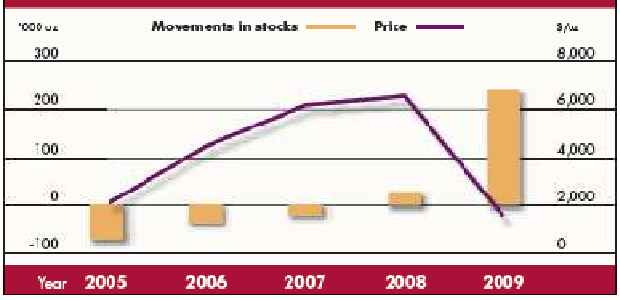
Rhodium Supply and Demand

	'000 oz	2005	2006	2007	2008	2009
Supply[1]	South Africa	627	666	696	574	663
	Russia[2]	90	100	90	85	70
	North America	20	17	20	18	15
	Zimbabwe[3]	13	14	14	15	19
	Others[3]	4	5	4	3	3
	Total Supply	**754**	**802**	**824**	**695**	**770**
Gross Demand by Application[4]	Autocatalyst[5]	829	863	887	768	619
	Chemical	48	49	63	68	54
	Electrical[6]	10	9	3	3	3
	Glass	57	65	59	34	19
	Other	20	23	24	24	21
	Total Gross Demand	**964**	**1,009**	**1,036**	**897**	**716**
Recycling[6]	Autocatalyst	(137)	(171)	(192)	(227)	(187)
	Total Recycling	**(137)**	**(171)**	**(192)**	**(227)**	**(187)**
	Total Net Demand[7]	**827**	**838**	**844**	**670**	**529**
	Movements in Stocks[8]	**(73)**	**(36)**	**(20)**	**25**	**241**

At a glance



Prices and Movements in Stocks



Average Price (US$ per oz)[9]

2005	2006	2007	2008	2009
2,056	4,552	6,191	6,564	1,592

8.2.4 Ruthenium and Iridium

Ruthenium and Iridium supply, demand and pricing over the period 2005 to 2009 are indicated in Table 8.2.8.

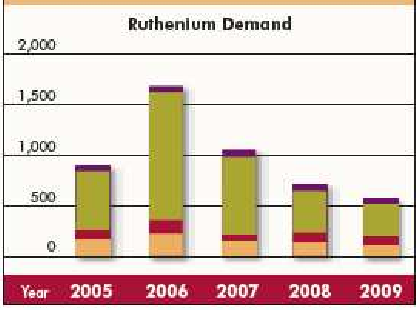
Table 8.2.8 Ruthenium and Iridium – supply, demand and price 2005 to 2009 (Johnson Matthey, 2010)

Ruthenium Demand

	'000 oz	2005	2006	2007	2008	2009
Gross Demand by Application	Chemical	164	223	151	139	89
	Electrical	582	1,272	776	410	336
	Electrochemical	96	137	62	95	95
	Other	49	54	69	55	54
	Total Gross Demand	891	1,686	1,058	699	574

At a glance

'000 oz



Average Price (US$ per oz)[9]

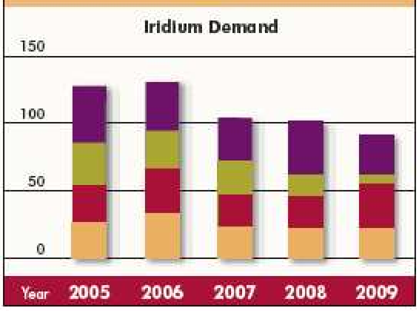
2005	2006	2007	2008	2009
75	192	580	323	95

Iridium Demand

	'000 oz	2005	2006	2007	2008	2009
Gross Demand by Application	Chemical	26	33	23	21	21
	Electrical	32	28	25	15	7
	Electrochemical	28	34	24	25	33
	Other	42	36	32	41	30
	Total Gross Demand	128	131	104	102	91

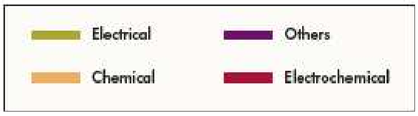
At a glance

'000 oz



Average Price (US$ per oz)[9]

2005	2006	2007	2008	2009
169	350	447	450	425



8.2.5 Demand – summary

Understanding of the market, specifically demand as the driver of sales revenue, is essential. This can be summarised as follows:

- It is important to note that the platinum market has a unique mix of created and derived demand, the combination of which creates flexibility and sustains price over periods of economic volatility;
- Current PGM revenues are concentrated in two end-use segments: automotive emission control and jewellery;
- The automotive segment accounts for about 60% of current market revenues and jewellery about 10%;
- Jewellery, as derived demand, acts as a counter-cyclical 'shock absorber' when the supply/demand balance shifts;
- The industrial demand segment demonstrates the versatility of PGMs and has achieved high growth rates from a low base; and
- Fuel cells and emission control in the stationary fossil-fuel burning sector are potentially large opportunities for PGMs that are, as yet, unrealised.

The current macroeconomic climate following the global economic crisis is expected to reduce forecast PGM demand growth in the near-term. The key drivers of this shift in demand being:

- Auto industry troubles have led to slowdown in motor vehicle production and increasing pressure to cut costs;
- Record fuel prices are driving a shift to more fuel efficient vehicles including smaller and/or hybrid vehicles which (depending on engine system design) may require lower PGM loadings;
- Slowing consumer spending is expected to hamper jewellery sales, especially in developed economies; and
- Economic weakness in North America and Europe is slowing chemical and industrial PGM demand.

Other aspects likely to negatively impact PGM demand growth in the near and medium-term are:

- Record PGM price levels have increased thrifting (catalyst loading reduction) efforts and substitution of platinum by palladium in the automotive segment, as well as slowed down PGM jewellery market penetration;

- Growth in recycling is accelerating due to current high PGM prices; and
- On a like-for-like basis the net effect of increasing thrifting, substitution and recycling is an estimated 10-15% drop in expected PGM revenues driven by reduction in overall PGM demand and changing metal mix.

However, medium- and long-term growth opportunities could expand the PGM market but will depend upon market development, new legislation and sponsorship by governments. Critical elements of this expansion relate to:

- Growth potential in BRIC economies' jewellery sector remains an opportunity; market penetration is low and markets could grow with increasing consumer income and spending but sustained market development is required.
- Broadening the scope of vehicle emissions legislation to include new pollutants and other vehicle types (e.g. buses, freight trucks) will expand PGM auto catalyst demand.
- Energy diversification and independence and regional environmental pressures are accelerating a shift toward alternative fuels and zero-emissions vehicles. PGM solutions (e.g. fuel cells) could lead to higher demand, but:
    - Competing technologies include battery electric vehicles which are not expected to use PGMs; and
    - Full-scale commercialisation of zero-emission technologies may require government support to induce investment.
- Currently, however, the auto industry continues to invest in PGM auto catalysts and ultra low emissions reduction solutions, with similar loadings to conventional auto catalysts.
- Increases in the cost of energy and societal change are making PGM-based fuel cell technologies attractive in new industry sectors such as:
    - Electricity generation;
    - Aviation (auxiliary power);
    - Portable power (e.g. substitute for batteries in laptops, cell phones); and
    - Marine.
- PGMs' unique attributes provide ongoing potential for new applications in a variety of industry sectors.
- PGM market fundamentals remain strong with growing demand for vehicles using auto catalysts in developing economies.

8.2.6 Pricing and exchange rate

Metal price is a crucial element of any form of business planning, short term or strategic. PGM prices are set in international markets, currently designated in US$, but the majority of world production ~70% arises from South African operations. The Rand / US$ exchange rate and the resultant Rand / oz PGM price is therefore critical. Given the physical nature of the mineralisation of the Bushveld Complex most production arises from labour intensive, narrow tabular mining operations. In narrow tabular, conventional mining, the most significant cost element is labour (at ~60% of cash cost) and is incurred as a local currency cost in Rand (ZAR).

Global PGM supply is therefore sensitive to the economics of production of South African PGM producers, with price responding rapidly to short supply variations caused by production interruptions (industrial action, energy supply shortfalls, safety stoppages, etc.) and the rate of development of new supply to market (the industry project pipeline).

Figures 8.2.1 and 8.2.2 show a 10 year price window, in US$ / oz for platinum and palladium respectively. Note that SMA 60 and SMA 200 denote simple moving averages over 60 and 200 day periods respectively.

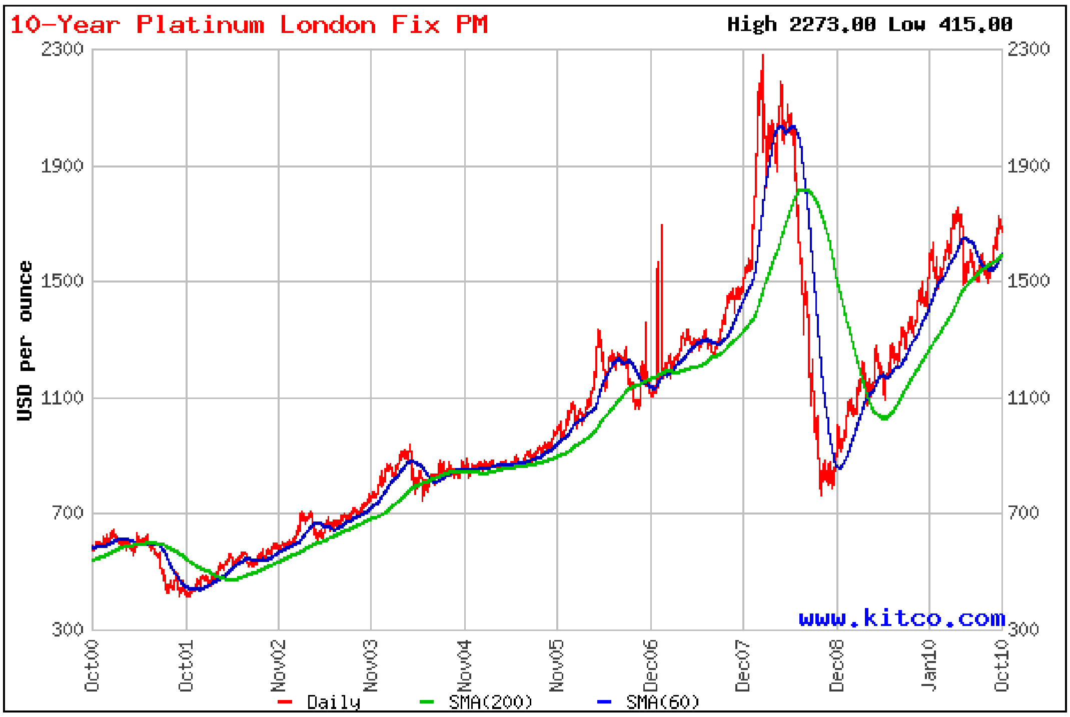


Figure 8.2.1 Platinum price: 2000 to 2010 (source www.kitco.com)

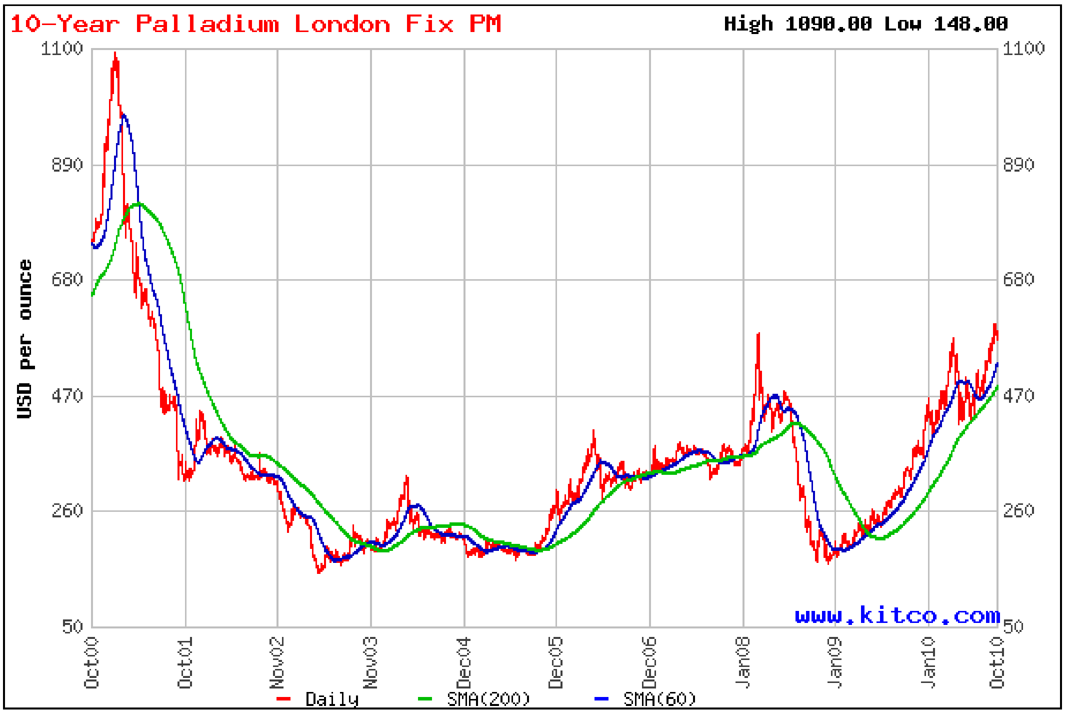


Figure 8.2.2 Palladium price: 2000 to 2010 (source www.kitco.com)

During late 2000 and early 2001 both the platinum and palladium prices rose to record highs with palladium trading near to US$1 100/oz, eclipsing platinum. These moves can be attributed to:

- Sales in the auto industry increased after declines in the previous three years. In the European car market, the share taken by diesel engines rose by almost one third and this, coupled with the imposition of Euro Stage III emissions legislation boosted platinum use;
- Platinum stock building by auto companies increased in anticipation of increased use to replace palladium following excessive price rises;
- Industrial demand for platinum increased (computer hard disks and speciality glass and liquid crystal displays);
- A fundamental imbalance developed over the period between supply and demand of palladium leading to excessive price rises and substitution for palladium by platinum in auto catalysts, electronics and dentistry. This imbalance can be attributed to erratic supply from Russian palladium stockpiles relating to regulatory conflicts;
- Poor supply performance from South African operations (labour unrest, flooding) was met by increased export from Russia but still resulted in a 1 Moz industry supply shortfall over two years. Delays in presidential approval of export quotas

and licences prevented sales in the first quarter of the year and it was not until April that metal began to flow to the west; and

- There were announcements of significant expansion plans by major South African producers (Anglo Platinum, Impala and Lonmin).

The period 2001 – 2005 showed a steady increase in PGM prices from a low in late 2001 as both derived and created demand steadily developed whilst supply from South African expansions lagged demand. Palladium prices returned to levels of ~US$260/oz as supply issues from Russia were resolved and the full impact of platinum substitution for palladium in auto catalysts took effect.

Late 2006 to 2007 showed a rapid spike in both Pt and Pd prices as a result of:

- Supply deficit of 480 koz following smelter closures, geological and safety problems and a difficult industrial relations climate;
- Adoption of stricter Euro IV emissions legislation in January 2006 coupled with an increase in the utilisation of particulate filters in medium and heavy duty diesel vehicles produced in Europe, Japan and North America;
- Booming sales in the electronics and glass sectors resulting in increased demand for both platinum and palladium;
- Platinum and palladium investment demand climbing significantly; and
- Rhodium prices rising to record highs (US$ 6 800/oz) resulting in significant thrifting in auto catalyst design.

The year 2008 shows the combined impact of then accelerating global economic growth coupled with the Eskom electricity supply crisis in South Africa followed by the global economic crisis. PGM prices achieved record highs, during the first half of the year, on the back of severe power supply disruptions and uncertainty in South Africa during a period of rampant global industrial growth. However following the global economic crisis which rapidly evolved during the second half, PGM prices crashed to five year lows as PGM demand evaporated during the adjustment of the global financial system. Subsequently PGM prices have steadily increased to more realistic levels as the global economy has equilibrated and demand returned to realistic levels.

Figure 8.2.3 shows the R/$ exchange rate over the same period.

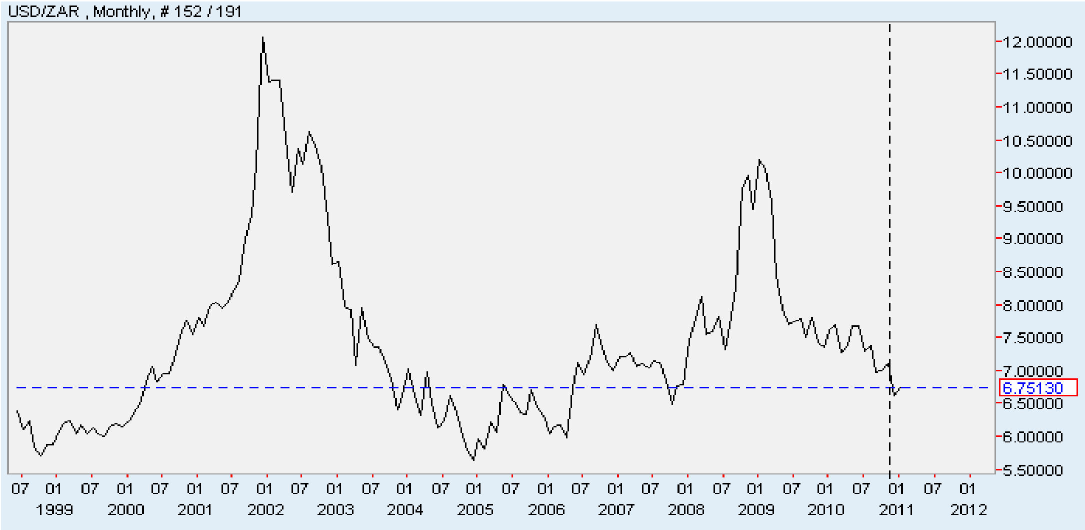


Figure 8.2.3 Rand / US$ exchange rate: 2000 to 2010 (www.ozforex.com.au)

Figure 8.2.4 indicates the relative movement in Rand basket price over the same period for mines in the Rustenburg area.

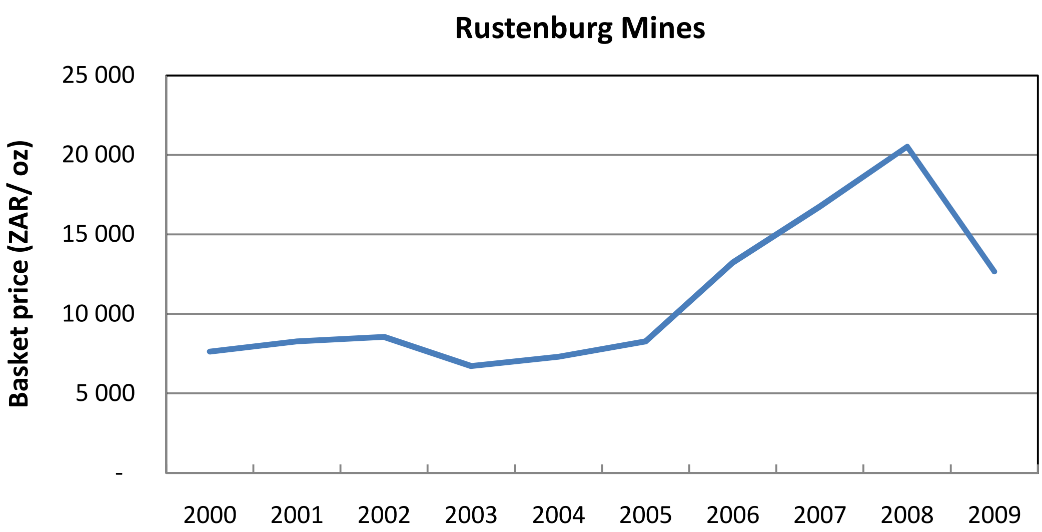


Figure 8.2.4 Rustenburg mines – basket price ZAR/oz

8.3 Supply

Historic supply data and commentary has been gleaned from a range of sources, primarily the Johnson Matthey Platinum 2010 review and annual reports of PGM producers. Commentary should be read in conjunction with the demand data provided in Section 8.2. The objective of these sections is to provide context and historical awareness of the market dynamics and variability, not specific analysis of the supply/demand/price dynamic of the PGM industry.

8.3.1 Introduction

Global supply of platinum and PGMs is dominated by South Africa and Russia, with South Africa accounting for 76.5% of platinum, 33.4% of palladium and 86.1% of rhodium supply during 2009. South African production is primary mined supply whilst Russian production is largely as a by-product of nickel and copper mining activities.

Limited production of PGMs also arises from North America and Zimbabwe. Small amounts of platinum group metals are produced as by-products of mining in a number of other countries including China and Colombia.

8.3.2 South Africa

Supplies of platinum from South Africa rose marginally to 4.53 Moz in 2009. The operational climate remained extremely difficult, with the industry hit by safety stoppages, strike action, smelter outages and geological issues, while production was also affected by the closure of a number of uneconomic shafts and pits. Palladium supplies decreased to 2.37 Moz while supplies of rhodium climbed to 663 koz.

Global supply is dominated by South African producers with Anglo Platinum producing 43.6% of global supply in 2009, Impala Platinum 25.2% and Lonmin 11.0%, collectively accounting for ~80% of world supply.

<u>Anglo Platinum</u>

Anglo Platinum sold 2.58 Moz of refined platinum in 2009, an increase of 16% (or over 350 koz) on 2008. Refined production of palladium rose by 3% to 1.36 Moz, boosted by expansion at the palladium rich Mogalakwena Mine, while rhodium output (which had been depressed by an increase in unrefined pipeline stocks the previous year) climbed by 17% to 350 koz. Shaft closures resulted in a fall in output at the Khuseleka and Siphumelele mines (formerly part of Rustenburg section), but this was offset by higher production from Mogalakwena – where platinum output rose by 26% to 237 koz – following the commissioning of the Mogalakwena North expansion project during 2008.

The amount of platinum processed on behalf of joint venture and pool-and-share operations also grew. Output from the Mototolo Mine – a 50:50 joint venture between Anglo Platinum and Xstrata – climbed by 25% to 109 koz of equivalent refined platinum production as the operation reached its rated capacity of 200 000 t/month of ore milled. Production also increased at Kroondal and Marikana. At the BRPM joint venture operation, a rise in headgrade and improved recoveries in metal processing were offset by poor ground conditions and equivalent refined production fell by 1% to 173 koz. At Modikwa – a joint venture with African Rainbow Minerals – platinum output also fell marginally, to 134 koz of equivalent refined production, owing to power supply problems and shortages of skilled labour. There was a decline in purchases of platinum from third parties, owing to lower output at Xstrata's Eland Platinum Mine (platinum group metals from this operation are refined by Anglo Platinum under a concentrate off-take agreement). Anglo Platinum's stated production target for 2010 was 2.5 Moz of platinum. However, the company revealed that production could rise by up to 200 koz above this level if the market demanded.

Impala Platinum

Output at Impala Platinum weakened during 2009, with platinum production from the Impala lease area falling by 12% to 867 koz in 2009, the lowest level for a number of years, while sales were down by 18% at 816 koz. Impala intends to grow platinum output from the lease area to 1 Moz annually within five years, but the outlook for the immediate future is flat, with the company forecasting production of around 860 koz in the financial year to June 2010. Impala Refining Services (IRS) refines platinum group metals on behalf of other mines, including the Zimplats and Mimosa operations in Zimbabwe (of which Impala holds 87% and 50% respectively), the Marula Mine on the eastern Bushveld (of which Impala owns 73%), and the Two Rivers joint venture with African Rainbow Minerals (of which Impala owns 45%). Additionally, IRS purchases and refines PGM bearing concentrate from a number of third party operations, as well as processing autocatalyst scrap. Excluding secondary scrap materials, refined platinum output from IRS rose by 8% to 627 koz in 2009. It should be noted that much of this increase relates to expansion in Zimbabwe.

Output at Marula continued to ramp up gradually, reaching 76 koz of platinum in concentrate in 2009. The mine is undertaking a switch from mechanised to conventional mining methods, but progress has been slower than previously anticipated and platinum output has grown slowly. At Two Rivers, the ramp-up to full production is now almost complete. Following optimisation of the concentrator plant, mill throughput rose by 7% to 2.8 Mt in 2009, while recoveries also improved; output climbed by more than a quarter, to

132 koz of platinum in concentrate. Once at steady state, production should climb to a rated annual capacity of 150 koz of platinum in concentrate.

Lonmin

Production of platinum in concentrate from Lonmin's operations fell by 9% to 652 koz in 2009, reflecting the decision to place the Limpopo Mine on care and maintenance, the closure of one uneconomic mine shaft and several half-levels at Marikana, and the cessation of open pit operations across the company's western Bushveld operations. After consistently declining since 2005, underlying performance at the company's main Marikana operation showed signs of stabilising, with production from the new vertical shafts, Hossy and Saffy, beginning to ramp up, offsetting the effects of safety stoppages at the two largest shafts, K3 and Rowland. A third new vertical shaft, K4, is under development and will begin to contribute to refined output in 2011. At the Pandora joint venture, plant throughput dropped by 26% to 650 000 t last year, following the decision to terminate open pit mining. However, ore continues to be extracted from underground via shaft infrastructure located on the adjacent Marikana Mine: output of platinum from this source totalled 40 koz in 2009.

Northam

At Northam's Zondereinde Mine, the quantity of newly-mined ore processed through the mills declined by 7% in 2009, to 2.02 Mt, however, production of PGM in concentrate was stable at 310 koz. For the first time, concentrate purchase contracts made a significant contribution to Northam's business. The company has an offtake agreement with Platmin's Pilanesberg Mine, which came on-stream in early 2009, and also processes small quantities of concentrate from other sources. In total, Northam purchased just under 50 koz of PGMs in concentrate last year, and this augmented the company's PGM sales: platinum shipments rose by 35% to 235 koz. In February 2010, Northam confirmed that development of its Booysendal project on the eastern limb of the Bushveld Complex would proceed during the year. The board has approved initial capital expenditure of R340 million, which will be used to build basic infrastructure such as roads and pipelines, in advance of the start of mine construction in mid 2010. The project is to be developed in a modular fashion, with the first phase costing some R3 billion and due to come on-stream in mid-2013. It is planned to extract 150 000 t/month of ore, yielding 130 koz of PGM annually including around 75 koz of platinum, with further expansion in later phases.

Aquarius Platinum

Aquarius Platinum operates four mines and two tailings retreatment operations in South Africa. At the Kroondal Mine, production of platinum in concentrate rose marginally to

241 koz in 2009, while the Marikana Mine saw a 7% increase in output, to 89 koz. Both these mines are operated under pool-and-share agreements with Anglo Platinum, which purchases all concentrate from Kroondal; output from Marikana is refined by both Anglo and IRS. The mine life of both operations was extended by the acquisition of First Platinum and Salene Mining in early 2010, with mineral rights in the vicinity of the Kroondal and Marikana mines.

Aquarius Platinum's Everest Mine was closed in December 2008, due to subsidence in mined-out levels of the mine around the decline shaft following a period of exceptionally heavy rainfall. A decision to redevelop the mine was taken in mid-2009, involving the construction of two new decline shafts to access the mining areas (which were unaffected by the subsidence) and will put the company in a position to resume milling ore in late 2010.

In July 2009, Aquarius acquired the UK company Ridge Mining, owner of a 50% stake in the Blue Ridge Mine, and a 39% stake in a large PGM/nickel project, Sheba's Ridge, which is undergoing feasibility studies. Blue Ridge came on-stream during the first half of 2009, and between July and December it produced just under 20 koz of platinum. The mine is ramping up towards full production, and platinum output should exceed 50 koz during 2011. Metal from both Blue Ridge and Everest is refined and marketed by IRS.

Aquarius also has 50% stakes in the Mimosa Mine in Zimbabwe, and in two tailings retreatment operations in South Africa: the Chromite Tailings Retreatment Plant (CTRP), based at the Kroondal Mine, and Platinum Mile, located on Anglo Platinum's Rustenburg lease area. These operations process tailings from adjacent chrome and platinum mining operations. Together, the two operations produced just less than 17 koz of platinum in 2009.

<u>ARM Platinum</u>

African Rainbow Minerals (ARM) is involved in three PGM producing mining ventures in South Africa. It has a 55% stake in the Two Rivers Mine (with the remaining 45% held by Impala), which started up in late 2006. This mine has enjoyed a relatively rapid ramp-up to full production, with platinum output of over 130 koz achieved in 2009.

ARM participates in a 50:50 joint venture with Anglo Platinum, the Modikwa Platinum Mine: this operation has now reached steady state production and recorded stable output of 134 koz of platinum in 2009. Further capital investment is expected to maintain output at this level. Finally, ARM and its joint venture partner Norilsk Nickel produced just under 30 koz of PGM as a by-product of nickel mining at the Nkomati Nickel mine; an expansion programme is currently being undertaken at this operation which will lift platinum group metal output to close to 100 koz annually.

Eastern Platinum

At Eastern Platinum's Crocodile River Mine, the tonnage of mined ore processed through the concentrator rose by 4%, while recoveries and grades also improved. Platinum group metal output climbed from 118 koz in 2008 to 130 koz in 2009, with sales of platinum in concentrate also rising by over 10% to 65 koz. In January 2010, the company announced the reactivation of development work at Crocette, a small section adjacent to the existing Crocodile River operations which had been on care and maintenance since November 2008. At full production, Crocette will contribute some 50 koz of PGM annually. The company has yet to confirm its plans for the Spitzkop project on the eastern Bushveld, the development of which was also put on hold in late 2008 owing to low PGM prices.

Other

Platinum Australia's Smokey Hills Mine commenced production in early 2009. In its first year of operation, the plant milled 487 000 t of ore, shipping around 27 koz of PGM in concentrate to IRS. The Smokey Hills concentrator is designed to treat 720 000 t of UG2 ore annually, which at full production should yield some 95 koz of PGM annually over a mine life of seven years.

Platmin's Pilanesberg open pit operation commenced mining operations in December 2008, with first delivery of concentrates to Northam taking place in April 2009. During 2009 the company shipped some 28 koz of PGM in concentrate; expected output is to rise to 160 koz in 2010, with full production (250 koz of PGM annually) being achieved during in 2011.

Sylvania Resources is developing a series of chrome tailings retreatment plants, known collectively as the Sylvania Dump Operations (SDO). Two further plants were commissioned during 2009, bringing the total to four, with a fifth due to be brought on-stream in May 2010. During 2009, SDO processed some 690 000 t of tailings, yielding 21 koz of PGM.

8.3.3 Russia

Reported Russian production during 2009 comprised 785 koz (13.2% of global supply) of platinum, 3 635 koz (51.2% of global supply) of palladium, of which 960 koz came from stockpiles and 70 koz (9.1% of global supply) of rhodium. Despite the significant input into the palladium market, most of this PGM production is considered to have arisen as secondary production from nickel and copper recovery activities.

Despite the relative importance of the Russian PGM mining industry to global PGM markets, information on reserves, production and sales has, historically, been difficult to obtain, as data was deemed confidential under the Russian State Secrecy Law. A bill was passed in late 2003 to declassify PGM information, with the exception of government stocks and sales, and took effect in February 2004, but publication of the PGM data appeared to have been delayed by regulatory procedures until a decree permitting the release of the data was signed in March 2005.

Russian PGM production is dominated by Norilsk Nickel, which produces platinum, palladium and minor PGMs from its copper-nickel mining and smelting complex in northern Siberia, and from its copper-nickel mines in the Kola Peninsula. Total production of platinum group metals from Norilsk Nickel's Russian operations fell slightly from 2008 levels. Palladium output decreased from 2.70 Moz to 2.68 Moz. Platinum output rose marginally from 632 koz in 2008 to 636 koz in 2009. Nickel production within Russia remained flat as Norilsk Nickel maintained domestic production but copper output fell, suggesting that the mix of ore being mined and processed at these Siberian operations was changed. Nickel production was forecast to rise marginally in 2010 while copper output was expected to fall, suggesting a decrease in the amount of cuprous ore to be mined. A 1% rise in palladium output from Norilsk Nickel's Russian operations to 2.72 Moz in 2010 and a 3% rise in platinum production to 655 koz was anticipated. Russia's most important source of PGM reserves is the PGM-containing copper-nickel deposits on the Tamyr Peninsula in northern Siberia. Exploitation of these deposits began in 1935. Four copper-nickel deposits were developed, during the 1960's at Talnakh, all of which are still in operation.

The large alluvial platinum deposits in Russia's Ural Mountains have been exploited since 1823. The deposits once represented the richest known underground sources of platinum, but have since been stripped of the highest-grade ore. From the 1920's, production from the Urals started to decline, to a point where the deposits now account for less than one percent of Russian platinum production. Small quantities of PGMs are also produced from copper-nickel deposits on the Kola Peninsula, and the past ten years have seen the exploitation of two alluvial deposits in the far-east region of Russia.

Supplies of platinum from other mining in Russia – mainly from alluvial mining operations in the far east of the country – decreased from 175 koz in 2008 to 150 koz in 2009. The largest of these, the Amur Mine, on the Kondjor deposit in the Khabarovsk region, produced marginally less platinum than in the previous year due to poor weather conditions. Platinum sales from the Korjak Mine fell to roughly 25 koz. No metal was supplied from the Inagli placer deposit which had produced almost 5 koz in 2008. Production from the Urals placer deposits fell slightly lower to close to 10 koz. Palladium output from these operations remains negligible.

It is estimated that 960 koz of palladium was sold from Russian state stocks during 2009. This is metal mined at Noril'sk in previous decades but never supplied to the market. There were large shipments of palladium from Russia to Switzerland in late 2007 and again in the second half of 2008, amounting to roughly 3 Moz in total. It is believed that around a third of this metal was priced and sold in 2008 and again in 2009 and that the remainder was scheduled for sale in 2010. Additionally, more than 10 t of palladium was shipped into Switzerland in early 2010, apparently from Russian state stocks.

8.3.4 North America

In 2005, North American platinum production, at 260 koz, accounted for 4.3% of total global production for the year. Palladium output was 755 koz (10.6% of global output) and rhodium 15 koz (1.9% of global production).

Supplies of palladium from North America declined from 910 koz in 2008 to 755 koz in 2009 due to the temporary closure of North American Palladium's Lac des Iles Mine and prolonged strike action at Vale Inco's Sudbury nickel operations. Supplies from Stillwater Mining's two Montana mines were almost unchanged despite a reduced workforce at the East Boulder property. Platinum supplies dropped from 325 koz to 260 koz. Rhodium sales decreased from 18 koz to 15 koz.

Stillwater Mining, the only US primary producer of platinum group metals, performed well during 2009, producing a combined 530 koz of palladium and platinum compared to 499 koz in the previous year. Palladium production rose from 384 koz to 407 koz while platinum output increased from 115 koz to 123 koz. In the second half of 2008, Stillwater responded to the low prevailing precious metals prices by refocusing its efforts on activity at its Stillwater property at the expense of the smaller, higher-cost East Boulder operation. Palladium accounts for about 75% of the production from the mine, with the remainder being platinum.

In Canada, PGMs are largely produced as a by-product of nickel mining. The Sudbury Basin, in central Ontario, discovered in 1883, has the largest number of PGM producing mines in the country. North American Palladium, the only primary producer of platinum group metals in Canada, temporarily closed its Lac des Iles Mine in Ontario in late October 2008 in response to low prevailing precious metals prices. In December 2009, North American Palladium responded to the strength of the palladium price by announcing that it would restart part of the Lac des Iles Mine in the second quarter of 2010. Mining was planned to take place at the Roby underground section to produce 140 koz of palladium per year over a two-year period. However, full production will not be reached until late 2010 and sales of refined metal were expected to remain at relatively low levels in 2009.

Vale Inco produced less platinum and palladium from its Canadian nickel operations in 2009 than in the previous year. Platinum output fell from 166 koz to 103 koz while palladium production dropped from 231 koz to 152 koz despite increased PGM recoveries. Most of this metal comes as a by-product from nickel mining at Vale Inco's Sudbury, Ontario mines. Its Copper Cliff South Mine was closed in late 2008 in response to low base metal prices. The remaining Sudbury operations were temporarily closed by the company in June 2009. Xstrata, the second major producer of nickel in Canada, maintained stable output during 2009 despite the closure of two of its mines and is on schedule to reach its full capacity of 1.25 Mt of ore in 2011.

8.3.5 Zimbabwe

All Zimbabwean PGM production is currently refined in South Africa. Zimbabwe PGM output during 2009 was 230 koz platinum (3.9% of global production), 180 koz palladium (2.5% of global output) and 19 koz of rhodium (2.5% of global output).

Zimbabwe's platinum deposits are located in a geological sequence known as the Great Dyke – an igneous intrusion 30 km wide and 550 km in length, spanning almost the length of Zimbabwe in a north-to-south direction.

Despite political tensions and a lack of clarity on indigenous equity ownership, investment in platinum operations is continuing in Zimbabwe. In early 2006, the Zimbabwean government announced that mining companies would have to surrender as much as 51% of their assets to the government, with 25% to be by way of a non-contributory stake, and the balance by way of a contribution over a period of time. Mining companies are continuing negotiations with the Zimbabwean government to ensure security of tenure and long term viability of operations.

Supplies of metal from Zimbabwe climbed significantly in 2009. Platinum supplies rose from 180 koz to 230 koz while supplies of palladium climbed too, rising from 140 koz to 180 koz, as expansion programmes continued at both operating mines on the Great Dyke. Output of platinum group metals (4E) at Mimosa – a joint venture between Aquarius Platinum and Impala – climbed from 160 koz to 194 koz during 2009. The Wedza 5.5 expansion was completed in May 2009, increasing mill capacity to 185 000 t and platinum group metal production capacity to nearly 200 koz per annum. Mill throughput rose by 21% to 2.24 Mt and production of platinum in concentrate increased by 22.2% to 99 koz. Annual palladium and rhodium production at Mimosa rose by similar percentages to 75 koz and 8 koz respectively.

Supplies of metal from Zimplats increased in 2009 with platinum production in matte rising to 131 koz. Palladium output rose to 104 koz and rhodium production reached 12 koz. The Phase 1 expansion project continued during the year and Portal 1 reached its full production capacity of some 100 000 t of ore per month in June 2009. Development of Portal 4 continues and should be complete by mid-2011. The Ngezi concentrator was commissioned in July 2009 and reached full capacity in September.

At Anglo Platinum's Unki Mine, also on the Great Dyke, development continued in 2009 and the first ore was stockpiled for processing once the concentrator was commissioned in the final quarter of 2010.

8.4 Porter's "five forces" analysis

The model of pure competition implies that risk-adjusted rates of return should be constant across companies and industries over time. However, different levels of profitability can be observed across these entities over time showing that competitive advantage can be achieved.

The seminal work done by Porter (1980), to develop a framework for industry analysis and business strategy, encompassed by the "five forces", can be applied to develop understanding of the industry context in which a business operates. The basic configuration of these "five forces" is indicated in Figure 8.4.1.

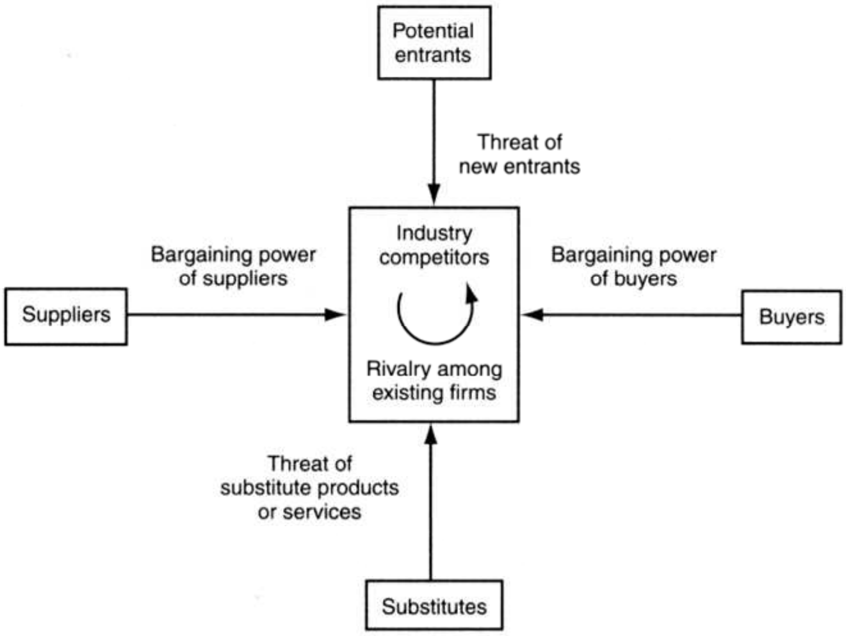


Figure 8.4.1 Porter's "five forces" model – original diagram (Porter, 1980)

The Porter "five forces" analysis is conducted through the identification and analysis of five competitive forces comprising:

- Entry of competitors. How easy or difficult is it for new entrants to start competing – what barriers to entry exist?
- Threat of substitutes. How easily can a product or service be substituted, or produced more cost effectively?
- Bargaining power of buyers. How strong is the position of buyers? Can they work together in ordering large volumes?
- Bargaining power of suppliers. How strong is the position of sellers? Do many potential suppliers exist or only few potential suppliers, is there a monopoly?
- Rivalry among the existing players. Does strong competition exist between the existing players? Is one player very dominant or are all equal in strength and size?

On this basis the original Porter diagram can be expanded as per Figure 8.4.2

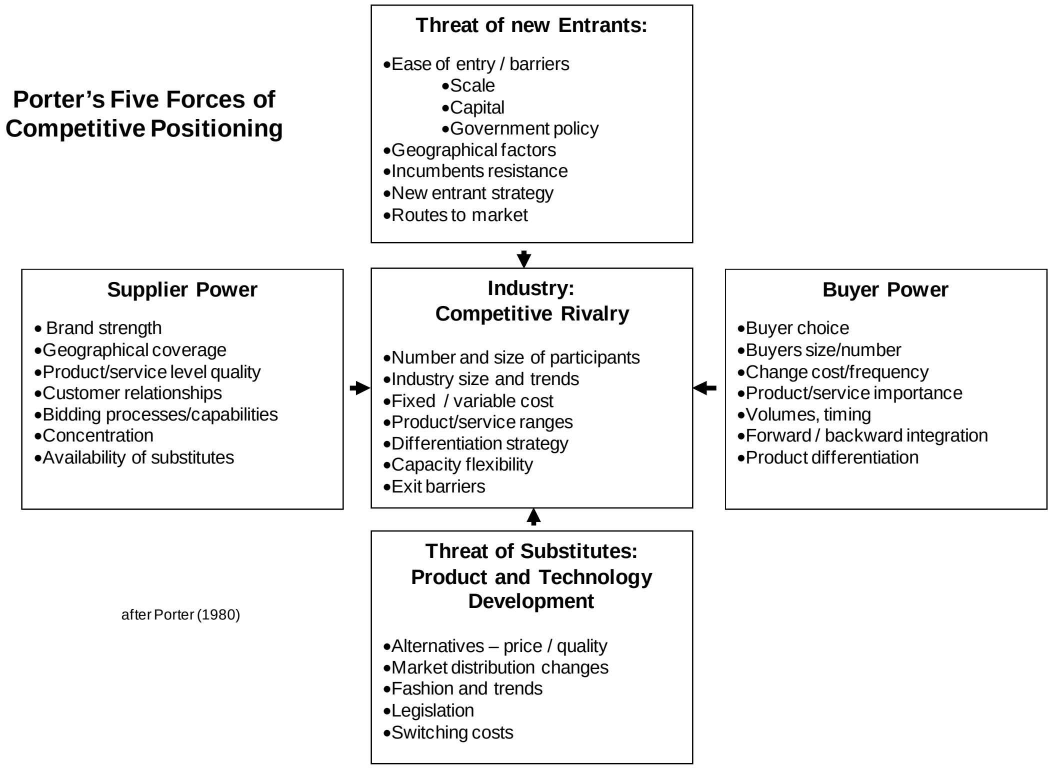


Figure 8.4.2 Generic Porter “five forces” (after Porter, 1980)

Application of the Porter analytical model provides the following insights:

8.4.1 Threat of new entrants

- 80% of known PGM mineral resources in the world occur in Southern Africa. These are already held or are being re-allocated;
- Security of tenure; the Mineral and Petroleum Resources Development Act (MPRDA) may result in some mineral assets being re-allocated through empowerment transactions;
- Likelihood of new extraction technology to extract PGMs from tailings;
- Recycling could increase from current 50% to 90%;
- Threat of other mineral deposits having high PGM content as by- metals;
- New, as of yet, undiscovered deposits;
- The general nature of the mineral resource (narrow tabular ore body) makes the industry labour and capital intensive;
- High fixed cost component;
- Alternate mining technology could change the cost structure of the industry;
- Skills shortages (technical) existing in South Africa;
- Projects generally have a long lead time to delivery;

- High capital requirements for mining and processing infrastructure;
- Optimisation of ‘farm boundaries’ (mergers and / or ‘pool and share’ agreements); and
- Opportunities for cross industry / commodity activities e.g. ferro-chrome.

8.4.2 Threat of substitute products or services

- Alternate energy for transportation; different mode of transport; mass transport of people; electric vehicles;
- A change in the ownership model of platinum, i.e. companies buy and then return it for recycling / exchange it for new material (buy once, own in perpetuity);
- Changes to legislation in the use of PGMs from a safety, health and environment perspective;
- Substitution across three areas (feed, process and product):
    - Feed - Ore bodies, a new technology opens up previously considered uneconomic reserves, recycled feed increasing;
    - Process - An improvement in concentrating and smelting technology relating to chrome content. The optimisation of roast reduction technology or a new heap leach process that skips the smelting phase; and
    - Product – Alternate to PGMs.
- Grades/quality, e.g. An end user finding a new ability to use lower grade product and backwardly integrating with a producer;
- Price rising too high and driving substitution and thrifting;
- Alternative to PGM jewellery demand (branded accessories such as handbags, cell phones, etc. taking buying precedence with new generation); and
- A breakthrough in technology to allow lower loadings of PGMs in autocatalysis applications, e.g. nano technology.

8.4.3 Bargaining power of buyers / users

- Fabricators are highly concentrated (80-85%). As such they influence the market through R&D and intellectual property;
- Consolidated end use – 60% of end use is for autocatalysis;
- Globally – large number of end users;
- The application/uses for PGM are counter cyclical to each other (autocatalysis, jewellery and investment);
- Typically, volume sale contracts are long term (~5 years);
- PGMs are a terminal market – price set by the market, producers are effectively price takers;

- Most demand for autocatalysis is driven by legislation;
- No real benefit to buyers in switching suppliers;
- PGMs are a very small percentage of end users total spend, but are a large percentage of fabricators spend;
- PGMs are fungible (i.e. product can be traded globally, without necessarily physically moving the product);
- The power to substitute can occur within limits. Efficient use of PGMs is in the interest of PGM suppliers; and
- The industry depends on supply-demand balance. Suppliers have marginal power in this regard.

8.4.4 Bargaining power of suppliers

- Large unionised labour force;
- Risk of disruption to operations – cost and supply impact;
- Sourcing of specialised mining services from third parties albeit that core mining activities are generally performed with own employees;
- Effective management of a limited pool of skilled engineering contractors;
- Large component of unskilled labour which impacts on productivity. Need to adapt mining methods to cater for this;
- Availability and security of energy and water resources;
- Availability of accommodation;
- Limited number of mechanised equipment suppliers;
- Limited and concentrated number of suppliers for key commodities (explosives, tyres, timber, chemicals and grinding media);
- Access and affordability of credit markets;
- Production capacity of supplier in times of high commodity cycles;
- Access to mining resources impacted by community relations – licence to operate;
- Community relations impacting relationship with government and NGOs; and
- Predictability and stability of regulatory framework.

8.4.5 Rivalry amongst existing competitors

- Limited geology – Bushveld Complex and Zimbabwe:
    - Anglo Platinum (AP) has 180 years resources, (+-60% of resources) which brings potential for longevity (and market dominance once other producers have run out);
    - Limited mergers and acquisition / industry consolidation opportunities due to competition and regulatory limitations;

    - Mostly deep level tabular mining due to nature of deposits – resulting in increasing costs with depth and distance from infrastructure; and
        - Only one significant long term open pit mining operation (Mogalakwena Mine); and
        - Prior to the refining stage there are very few technology differentiators.
    - Geographical location of ore bodies results in competition for access to infrastructure and services (electricity, water, etc.).
- Mature market
    - Stable competitors – Anglo Platinum / Impala / Lonmin / Aquarius are ~80% of market supply; and
    - Possible consolidation of the smaller platinum producers to form a 5th major player.
- Regulatory environment through BEE has defined the SA competitive landscape
    - MPRDA and mining charter have resulted in an increased number of empowerment driven joint ventures.
- Cost curve positioning
    - Owing to high industry producer concentration (80% across four producers) relative movement creates significant change in producer cost positioning and limited opportunity to sell high cost assets and buy low cost assets. Reducing cost therefore limited to organic structuring and asset optimisation; and
    - Benchmarking is crucial.
- Moral (social and legal) licence to operate is key to business longevity
    - Variable by community; and
    - Affects longer term cost structures.

8.4.6 Market context – summary

Within this context, the overall market context can be summarised as per Figure 8.4.3.

Whilst the key characteristics that may reduce the attractiveness of the PGM industry, going forward, could be considered as:

- Increased risk to social licence to operate;
- Constrained supply of critical utilities – water and electricity; and
- Substitution and resulting changes in demand mix.

	PGM	Platinum	Palladium	Rhodium
Market Size	• $20bn revenue (2007) • $7bn op profit (2007) • Volume: 14m ounces	• $9bn revenue (2007) • Volume: 6.6m ounces	• $3bn revenue (2007) • Volume: 6.9m ounces	• $5bn revenue (2007) • Volume: 0.9m ounces
Market Growth		• 8% Autocat (1997-2007) • 4% industrial (2003-2007) • -4.6% Jewellery (1997-2008)	• 3% Autocat (1997-2007) • -6% Industrial	• 8% Autocat (1997-2007) • 5% Industrial
Profitability	• 51% 2007 EBIT margin • 43% 2007 NOPAT margin			
Price Volatility & Growth		• 31% price volatility (1989–2009) • -0.4% pa real price growth (1989-2009)	• 43% price volatility (1989–2009) • -1.5% pa real price growth (1989-2009)	• 77% price volatility (1992–2009) • -6.0% pa real price growth (1991-2009)
Supply/Demand Balance	• Historically been in deficit • Large reductions in stocks in 2008 have cleared deficit • Large demand reductions, countered by near term supply reductions, leaving market in balance		• Historically been in surplus • Supply is expected to fall due to lower output from Russia and depletion of Russian stockpiles… …Driving the market in a deficit	• Historically market has been in deficit • Rhodium is mined as a by-product • With a shrinking market; due to lack of end use applications, thrifting and increased recycling Rhodium is moving into a strong surplus

Figure 8.4.3 Market context – summary

8.4.7 Industry and competitor analysis

Revisiting the Porter analysis framework on an annual basis is an integral part of the strategy development process. In order to effectively exercise this process it is necessary to develop a set of underlying data and information to inform the process and participants.

This data and information comprises:

- A market information and intelligence information repository;
- Financial models simulating competitors businesses (financial models in same format as own operations to allow comparison and consolidation into an industry model);
- An industry and competitor analysis; and
- Cost curve analysis

The market information and intelligence repository is a compilation of data on all aspects of the industry. Typically this can be summarised into an executive summary of key information termed a ‘fact base’.

Financial models are built of all major competitors operations and businesses in order to simulate overall industry dynamic. This information is a critical input into metal pricing analysis.

Typically the industry and competitor analysis would comprise content elements such as:

- PGM industry (by participant – asset base, resources and reserves, operations summary, financial analysis, projects, capital intensity);
- Exploration strategies, mergers and acquisitions;
- Supplier analysis;
- Country analysis;
- National legislative – trends and impact;
- Corporate social investment; and
- Scenario or world view analysis (current world views, signposting, driving forces).

Industry cost curves and investment break-even analysis

Industry operating cost curves allow understanding of relative competitive positioning based on cost and give an indication of what proportion of overall industry production is price sensitive and at what level.

The incentive price is the metal basket price, typically expressed in ZAR or US$ per ounce of platinum, at which projects/operations are expected to meet the required investment hurdle rate for the industry. This hurdle rate allows for minimum expected investment return plus a risk premium.

The long term incentive price is calculated as follows:

- Discounted cash flow models are established for known and anticipated industry operations and projects:
    - The long term planning parameters encompassed in the global assumptions (see Section 11.5 – metal prices, exchange rates, inflation rates, capital and operating cost escalation rates) are applied uniformly to best estimates of production rates, operating costs and capital requirements.
    - Additional downstream processing capacity is estimated and capital allocated to each project. The quantum of the capital cost, calculated at the project steady state production, is distributed over the build period for each project.

    - The NPV (real terms) is calculated at an appropriate hurdle rate (4% - 6%).
- For each operation/project in the industry, the required basket price (in ZAR) to break even (i.e. when the NPV at the hurdle rate equals zero) is determined using their respective valuation models. This is achieved by flexing the PGM prices in the valuation model until $NPV_{x\%\ real} = 0$ is achieved for the assumed set of metal ratios associated with the operation/project.
- The break-even basket prices for each project/operation are arranged cumulatively from lowest to highest, using their steady state production. This cumulative chart representation (y axis break-even incentive price, x axis cumulative production in Moz or percentage) of existing and anticipated metal production ranked by incentive price indicates potential supply that is viable at a given price expectation. The chart thus provides a perspective of anticipated future supply (based on an assumed world view or scenario encompassed in the global assumptions – see Section 11.4) at a minimum metal price to achieve targeted return represented by the selected hurdle rate.
- Anticipated industry demand, associated with the future world view, can then be overlain to highlight shortfall or excess of supply.

This approach allows the identification of a long term price which is necessary for industry production to come on stream to meet anticipated demand in a scenario of increasing demand, if undue price increases are to be avoided. Conversely it identifies the amount of metal which must be removed from the market when supply exceeds demand to avoid oversupply and metal price reductions. See Figure 8.4.4.

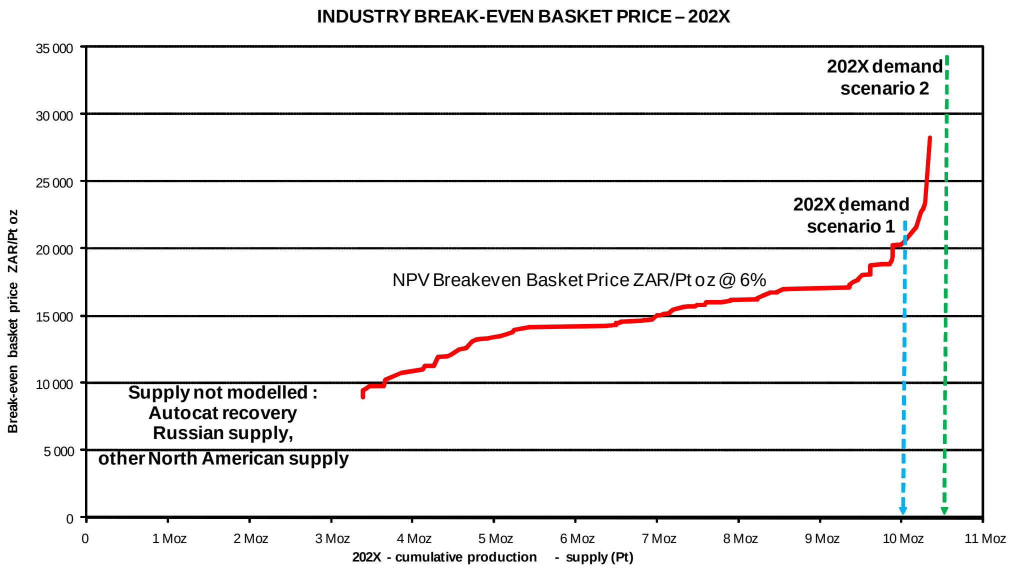


Figure 8.4.4 Typical investment break-even analysis chart

This link between world views or scenarios and metal price is critical and accommodated in the development of the global assumptions (see Section 11.5), in which the incentive price is used as the long term price forecast, based on the desirability of maintenance of a balanced market.

Industry cost curves are the near term manifestation of the incentive price curve, in that they represent the cash operating cost of cumulative industry production from existing operations and announced investments (see Figure 8.4.5). Viability of operations and potential risk to supply can be assessed from their position on the cost curve and comparison with current and near term metal price forecasts.

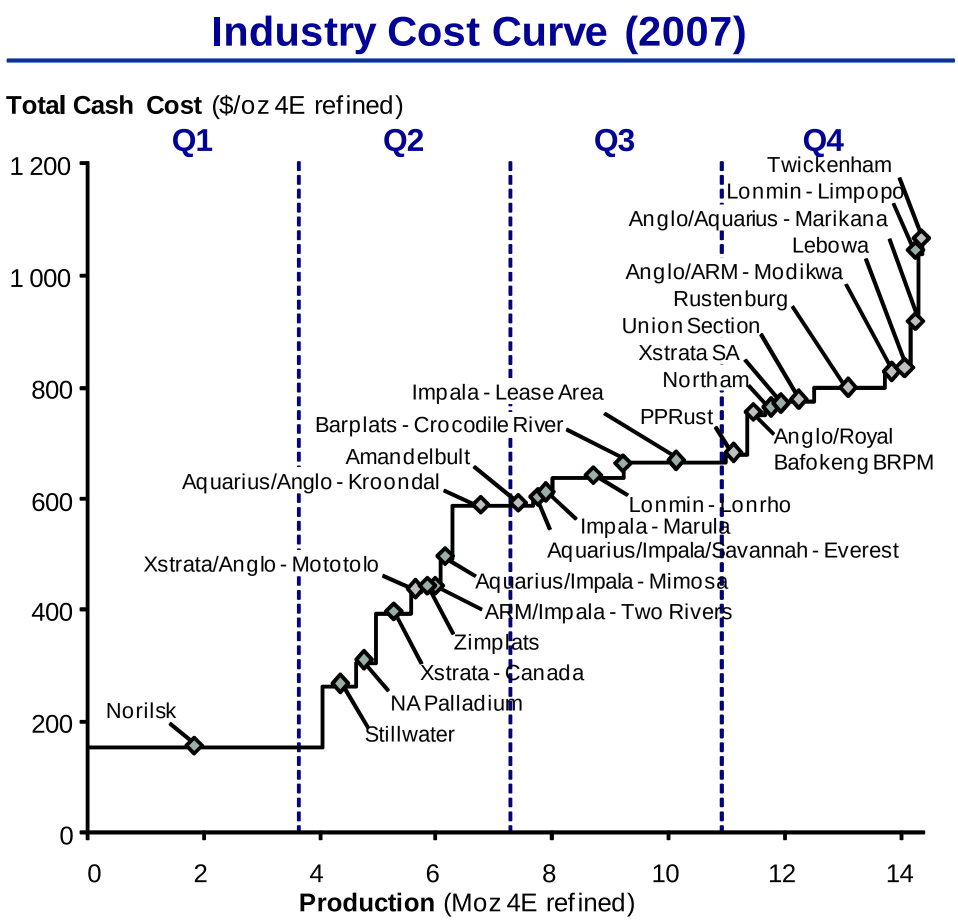


Figure 8.4.5 Industry cash cost curve – 2007 (after Anglo Platinum Limited, Industry and Competitor Analysis 2007)

Several factors must be considered in the development and utilisation of costs curves:

- Adjustment for reporting periods (money terms);
- Effect of by-metal revenues: Typically cash cost curves are net of by-metal to allow for variation of metal ratios and differing base metal content across the different reef horizons;
- Inclusion / exclusion of stay-in-business capital: Not all companies are explicit in the reporting of SIB capital, which may be grouped with expansion or replacement project capital, and difficult to identify and separate, or simply included as a cash cost; and
- Other costs: Despite public reporting standards it is often difficult to ascertain what centralised or shared cash costs have been included in cash cost declarations.

It is important to maintain a consistent approach to data as the cash cost curve provides relative comparison with assumptions being drawn on the relative positions of operations to each other and an assumed price line. Similar to the incentive pricing approach, cash cost curves can be developed for future scenarios. Assumptions are made on metal production, cost management and capital efficiency in order to develop a cash cost curve for a particular date, from which to develop a view on supplier composition.

8.5 Contribution to the Conceptual Framework

The market is the key determinant of overall business strategy in the PGM industry. Key observations that can be made are:

- The PGM industry is an attractive industry due to concentration of producers and a broad portfolio of end-use applications that provide sustainable long term demand growth.
- In the near term PGM demand for autocatalysis is expected to grow, driven predominantly by tightening emissions legislation and expanding vehicle markets, primarily in China and India.
- Demand for platinum in fuel cells is expected to be driven by growth in stationary and portable energy applications.
- Platinum and palladium demand for jewellery applications is expected to increase, driven by increased affluence in the east, especially China.

- PGM pricing is driven by anticipated supply and demand (derived and created), with created jewellery demand being negatively correlated with price and providing a measure of protection against sustained excessively high or low prices.
- Longer term reduction in the dependence on fossil fuels will lead to a reduction in use of conventional internal combustion engines for portable energy sources. PGMs have an important role to play in longer term, alternative portable energy sources, and in near term hybrid applications. However continuous investment in product development is required to ensure long term relevance of PGMs in the energy sector.

It is necessary to have a concise means of condensing market understanding and intelligence into a form that is accessible to the strategy and executive teams to inform decision making.

Within the Strategic Long Term Planning Framework the key tools to facilitate this are:

- The Porter “five forces” analysis;
- Market information in the form of a ‘fact base’;
- An annual industry and competitor analysis; and
- Industry cost curve analysis.

Critically, the interpretation of market understanding and intelligence manifests in the strategic long term planning framework through world view or scenario development and the associated global assumptions that are applied throughout the business planning process. Understanding of the market and the environment in which it functions (part A of Figure 3.1) informs the building of world views or scenarios and the associated global assumptions that are used to develop and optimise the investment centres that comprise the business plan.

9 THE GLOBAL BUSINESS ENVIRONMENT

The global business environment can be defined as the global environment that influences local decision making on resource use and capabilities. This includes the social, political, economic, regulatory, tax, cultural, legal and technological environments.

As businesses have no control over the external environment, their success depends upon how well they adapt to the external environment. A business's ability to design and adjust its internal variables to take advantage of opportunities offered by the external environment, and its ability to control threats posed by the same environment, determine its success.

In Figure 3.1, the schematic representation of the key components of the conceptual framework, the global business environment is placed between the characteristics of the mineral resource and the market / value chain. This represents the filtering effect that elements of the global business environment have on market demand and selection of orebodies for mining.

Within this context this chapter focuses on the elements critical to the platinum mining industry specifically environmental legislation, technology and the global economic context.

9.1 Environmental

The critical environmental factor in the development of the PGM industry has been that of emissions control through legislated standards. Emission standards are requirements that set specific limits to the amount of pollutants that can be released into the environment.

Background

In 1966 "automobile tailpipe" emission standards for hydrocarbons (HC) and carbon monoxide (CO) were adopted in California in response to smog in the city of Los Angeles. Initial emissions regulations were met by engine modifications, but in 1975 the first two-way (or oxidation) catalytic converters came into use as part of the Motor Vehicle Emission Control Program of the California Air Resources Board (CARB). They were followed a year later by the first three-way catalytic converters, to control HC, CO and nitrogen oxides (NO_x). Much of the world has followed this initiative by introducing limitations on allowable emissions.

Autocatalysis (adapted from Johnson Matthey)

The first catalysts used a simple formulation of platinum deposited on aluminium oxide which in turn was coated onto a support material so that it could be placed in the exhaust stream of the vehicle. These designs were essentially two-way oxidation catalysts, so called because they reduce emissions of both carbon monoxide and hydrocarbons by oxidising them to carbon dioxide and water. Later, researchers developed the now commonplace three-way catalysts (for petrol or gasoline vehicles) in order to meet tighter emissions legislation. In a three-way catalyst (TWC), carbon monoxide and unburnt hydrocarbons are oxidised at the same time as NO_x emissions are reduced to water and nitrogen. Originally, TWCs used platinum and rhodium as the catalytically-active components. Palladium analogues of these platinum catalysts were developed later and have since become the dominant technology on light duty petrol or gasoline vehicles in most regions. A diesel oxidation catalyst (DOC) functions by oxidising carbon monoxide and any unburnt hydrocarbons over a platinum group metal. Normally such reactions would only take place at very high temperatures but the use of a catalyst allows them to proceed at much lower temperatures (Johnson Matthey, 2004).

Emissions standards

In the United States, emissions standards are managed by the Environmental Protection Agency (EPA). California's emissions standards are set by the California Air Resources Board (CARB). Sixteen other States had adopted CARB rules as of mid 2009. CARB policies have also influenced EU emissions standards. Federal Tier 1 regulations went into effect in 1994 with Tier 2 standards being phased in from 2004 to 2009. The US has tightened emissions standards 96-99% from 1970 in areas such as hydrocarbons and NO_x.

The European Union (EU) has a set of emissions standards that all new vehicles must meet. Currently, standards are set for all road vehicles, trains, barges and 'non-road mobile machinery' (such as tractors). No standards apply to seagoing ships or aeroplanes. The EU introduced Euro IV effective January 1, 2008, Euro V effective January 1, 2010 and Euro VI effective January 1, 2014. The EU has already tightened emissions standards 83-85% from 1992 in areas such as hydrocarbons, but next generation standards are focused on diesel vehicles. Stricter emission standards for diesel vehicles are due in 2014. Currently NO_x levels permitted for diesel vehicles are four to five times higher than for petrol or gasoline vehicles

China enacted its first emissions controls on vehicles, equivalent to Euro I standards, in 2000 with an upgrade to the Euro II standard in 2004. National Standard III, equivalent to Euro III standards, went into effect in 2007. Plans were for Euro IV standards to take effect in 2010. Beijing introduced the Euro IV standard in advance on January 1, 2008, becoming the first city in mainland China to adopt this standard. China has already tightened emissions standards 83-85% from 2000 in areas such as hydrocarbons; next generation standards are shifting focus towards other areas (Dieselnet.com [online]).

India adopted the European emission and fuel regulations for four-wheeled light and heavy duty vehicles in 2000 with specific regulations for two- and three-wheeled vehicles. In 2010 the Bharat Stage III emission norms for 4-wheelers were to be implemented for the entire country with Bharat Stage IV (equivalent to Euro IV) to apply in thirteen major cities(Dieselnet.com [online]).

Japan introduced the Motor Vehicle NO_x Law to cope with NO_x pollution problems from existing vehicle fleets in highly populated metropolitan areas in 1992. This regulation was amended in June 2001 to tighten the existing NO_x requirements and to add particulate matter control provisions (Dieselnet.com [online]).

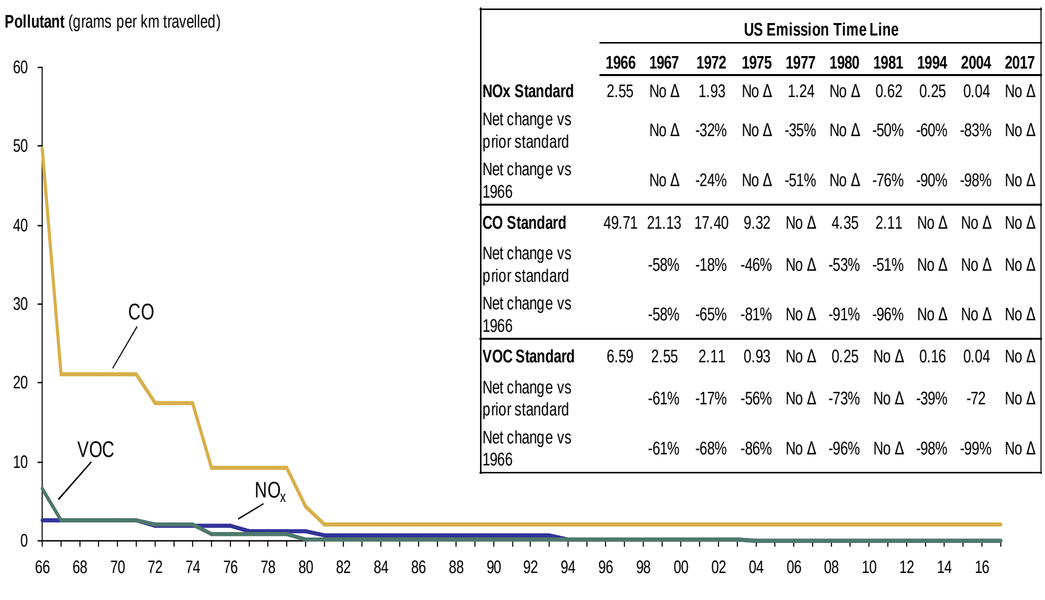
Current global emission standards are thus a mix of national and regional standards (see Table 9.1.1) with a global standard envisaged by the G8 by 2050. Standards generally regulate the emissions of nitrogen oxides (NO_x), sulphur oxides, particulate matter (PM) or soot, carbon monoxide (CO), or volatile hydrocarbons.

Table 9.1.1 Global emission standards – summary (after Impala, 2007)

<table>
<tr><th></th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>207</th><th>2008</th><th>2009</th><th>2010</th></tr>
<tr><td>Argentina</td><td colspan="3">Euro I</td><td colspan="2">Euro II</td><td colspan="5">Euro III</td></tr>
<tr><td>Australia (petrol)</td><td colspan="2">Euro I</td><td colspan="3">Euro II</td><td colspan="5">Euro III</td></tr>
<tr><td>Australia (diesel)</td><td colspan="2">Euro I</td><td colspan="4">Euro II</td><td colspan="4">Euro IV</td></tr>
<tr><td>Brazil</td><td colspan="5">Euro II</td><td colspan="5">Euro III</td></tr>
<tr><td>Columbia</td><td colspan="10">Euro I</td></tr>
<tr><td>Russia</td><td colspan="5">Euro I</td><td colspan="3">Euro II</td><td colspan="2">Euro III</td></tr>
<tr><td>Vietnam</td><td colspan="6">Euro I</td><td colspan="4">Euro II</td></tr>
<tr><td>Singapore (petrol)</td><td colspan="10">Euro II</td></tr>
<tr><td>Singapore (diesel)</td><td colspan="5">Euro II</td><td colspan="5">Euro III</td></tr>
<tr><td>Hong Kong</td><td colspan="5">Euro III</td><td colspan="5">Euro IV</td></tr>
<tr><td>Mexico</td><td colspan="2">Euro II</td><td colspan="8">Euro III</td></tr>
<tr><td>China (petrol)</td><td colspan="3">Euro I</td><td colspan="3">Euro II</td><td colspan="3">Euro III</td><td>E IV</td></tr>
<tr><td>China (diesel)</td><td colspan="2">Euro I</td><td colspan="4">Euro II</td><td colspan="3">Euro III</td><td>E IV</td></tr>
<tr><td>India (nation)</td><td colspan="4">Euro I</td><td colspan="5">Euro II</td><td>E III</td></tr>
<tr><td>India (10 cities)</td><td colspan="2">Euro I</td><td colspan="2">Euro II</td><td colspan="5">Euro III</td><td></td></tr>
<tr><td>Korea (petrol)</td><td colspan="2">Korea 2000</td><td colspan="3">Korea 2004</td><td colspan="5">CA ULEV</td></tr>
<tr><td>Korea (diesel)</td><td colspan="2">Korea 2000</td><td colspan="3">Korea 2004</td><td colspan="5">Euro IV</td></tr>
<tr><td>Thailand</td><td colspan="3">Euro II</td><td colspan="5">Euro III</td><td colspan="2">Euro IV</td></tr>
</table>

Figures 9.1.1 to 9.1.4 indicate specific emission standards for the USA, the European Union and China, indicating future requirements. Note “No Δ” indicates no change on previous year.

US Standards – Gasoline Passenger Vehicles



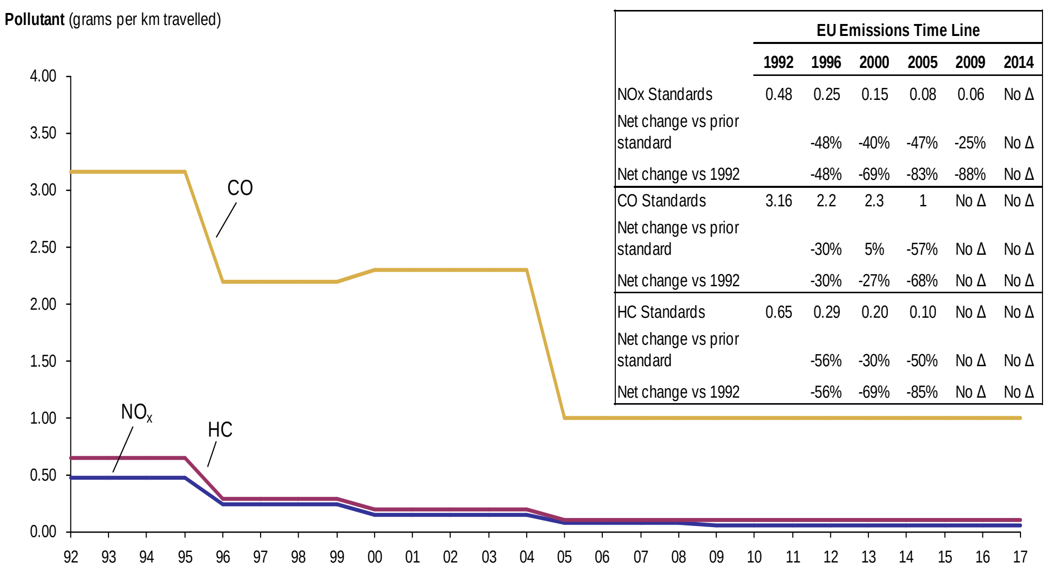
	US Emission Time Line									
	1966	1967	1972	1975	1977	1980	1981	1994	2004	2017
NOx Standard	2.55	No Δ	1.93	No Δ	1.24	No Δ	0.62	0.25	0.04	No Δ
Net change vs prior standard		No Δ	-32%	No Δ	-35%	No Δ	-50%	-60%	-83%	No Δ
Net change vs 1966		No Δ	-24%	No Δ	-51%	No Δ	-76%	-90%	-98%	No Δ
CO Standard	49.71	21.13	17.40	9.32	No Δ	4.35	2.11	No Δ	No Δ	No Δ
Net change vs prior standard		-58%	-18%	-46%	No Δ	-53%	-51%	No Δ	No Δ	No Δ
Net change vs 1966		-58%	-65%	-81%	No Δ	-91%	-96%	No Δ	No Δ	No Δ
VOC Standard	6.59	2.55	2.11	0.93	No Δ	0.25	No Δ	0.16	0.04	No Δ
Net change vs prior standard		-61%	-17%	-56%	No Δ	-73%	No Δ	-39%	-72	No Δ
Net change vs 1966		-61%	-68%	-86%	No Δ	-96%	No Δ	-98%	-99%	No Δ

Source: US Department of Transportation. Notes: CO = Carbon Monoxide, NO$_x$= Nitrogen Oxide, VOC = Volatile Organic Compounds.

Figure 9.1.1 Summary of emission standards – USA – petrol /gasoline vehicles (after Anglo Platinum, Industry and Competitor Analysis, 2009)

No material shifts in emissions standards in the USA are anticipated, to alter current PGM consumption patterns in petrol autocatalysis.

EU Standards – Gasoline Passenger Vehicles

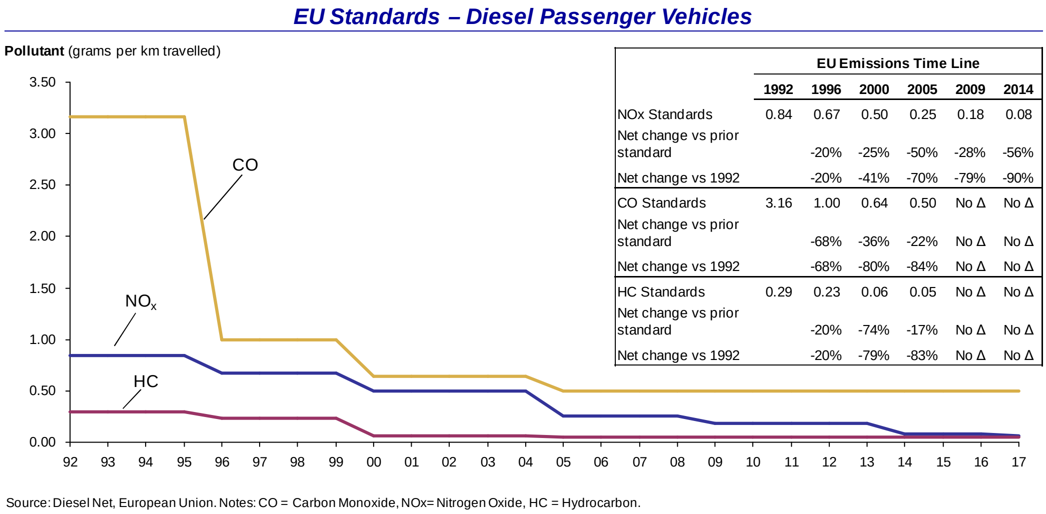


	EU Emissions Time Line					
	1992	1996	2000	2005	2009	2014
NOx Standards	0.48	0.25	0.15	0.08	0.06	No Δ
Net change vs prior standard		-48%	-40%	-47%	-25%	No Δ
Net change vs 1992		-48%	-69%	-83%	-88%	No Δ
CO Standards	3.16	2.2	2.3	1	No Δ	No Δ
Net change vs prior standard		-30%	5%	-57%	No Δ	No Δ
Net change vs 1992		-30%	-27%	-68%	No Δ	No Δ
HC Standards	0.65	0.29	0.20	0.10	No Δ	No Δ
Net change vs prior standard		-56%	-30%	-50%	No Δ	No Δ
Net change vs 1992		-56%	-69%	-85%	No Δ	No Δ

Source: Diesel Net. Notes: CO = Carbon Monoxide, NOx= Nitrogen Oxide, HC = Hydrocarbon.

Figure 9.1.2 Summary of emission standards – European Union – petrol vehicles (after Anglo Platinum, Industry and Competitor Analysis, 2009).

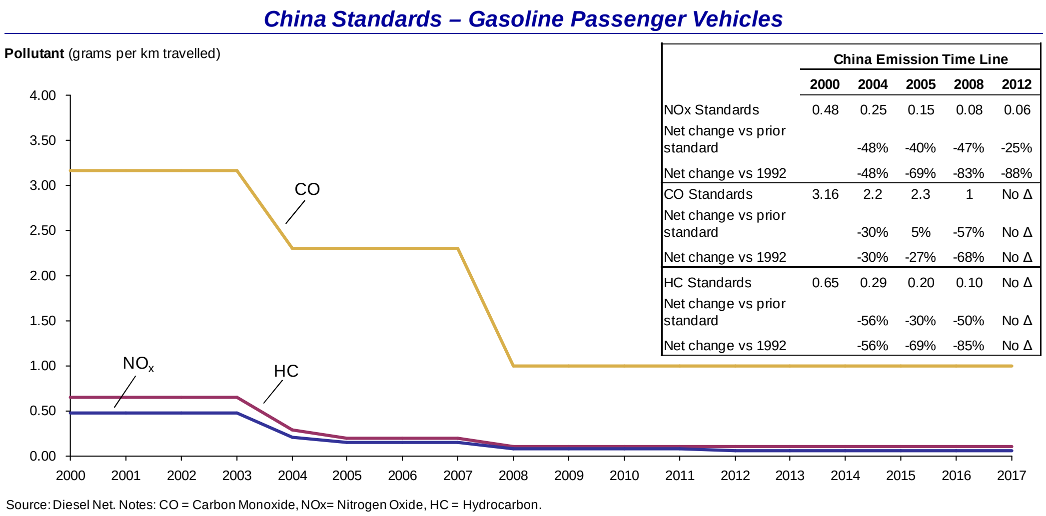
Increased stringency in NO_x emissions control in the EU post 2010 is likely to impact catalyst loadings.



	EU Emissions Time Line					
	1992	1996	2000	2005	2009	2014
NOx Standards	0.84	0.67	0.50	0.25	0.18	0.08
Net change vs prior standard		-20%	-25%	-50%	-28%	-56%
Net change vs 1992		-20%	-41%	-70%	-79%	-90%
CO Standards	3.16	1.00	0.64	0.50	No Δ	No Δ
Net change vs prior standard		-68%	-36%	-22%	No Δ	No Δ
Net change vs 1992		-68%	-80%	-84%	No Δ	No Δ
HC Standards	0.29	0.23	0.06	0.05	No Δ	No Δ
Net change vs prior standard		-20%	-74%	-17%	No Δ	No Δ
Net change vs 1992		-20%	-79%	-83%	No Δ	No Δ

Figure 9.1.3 Summary of emission standards – European Union – diesel (after Anglo Platinum, Industry and Competitor Analysis, 2009).

The European market favours light diesel engines, impacted by the progressive reduction of NOx emissions. The Euro V emissions rules due to be applied to new light duty vehicle models in late 2009 (and to all new cars in early 2011) effectively mandate the fitment of diesel particulate filters (DPFs) to new diesel models. This should add to overall platinum demand.



	China Emission Time Line				
	2000	2004	2005	2008	2012
NOx Standards	0.48	0.25	0.15	0.08	0.06
Net change vs prior standard		-48%	-40%	-47%	-25%
Net change vs 1992		-48%	-69%	-83%	-88%
CO Standards	3.16	2.2	2.3	1	No Δ
Net change vs prior standard		-30%	5%	-57%	No Δ
Net change vs 1992		-30%	-27%	-68%	No Δ
HC Standards	0.65	0.29	0.20	0.10	No Δ
Net change vs prior standard		-56%	-30%	-50%	No Δ
Net change vs 1992		-56%	-69%	-85%	No Δ

Figure 9.1.4 Summary of emission standards – China (after Anglo Platinum, Industry and Competitor Analysis, 2009).

Chinese emission standards have effectively aligned with Europe. The greatest impact here will be the volume of units to service the Chinese market.

Summary

Emissions legislation has been the key driver of PGM demand since the mid 1990's. Increasingly strict legislation for vehicle emissions drives and supports PGM consumption for emissions control. However the positive impact of emissions legislation on PGM autocatalyst demand may now diminish with modest or no impact from enacted legislation on ~80% of global production. Critical observations are:

- Although most nations have implemented their own emission standards, the G8 envisions a global emission standard by 2050.
- The US has tightened emissions standards 96-99% from 1970 in areas such as hydrocarbons and NOx. However no stricter emission standards for passenger vehicles beyond 2004 have been enacted.
- European Union:
    - Emissions standards for petrol / gasoline vehicles have been tightened 83-85% from 1992 in areas such as hydrocarbons, but next generation standards are focused on diesel vehicles; and
    - Stricter emission standards for diesel vehicles are due in 2014 as NO_x and PM for diesel vehicles are currently four to five times higher than for gasoline vehicles.
- China has already tightened emissions standards 83-85% from 2000 in areas such as hydrocarbons.
- Next generation emission standards are shifting focus towards additional pollutants, as well as broadening scope to include, e.g. non-road and marine vehicles.
- Emission legislative scope is broadening in the near to medium term:
    - Geographically;
    - With regard to particulates; and
    - Heavy duty and off-road vehicles.

9.2 Technology

Platinum group metal demand, as indicated in Section 8.2, is driven by four key sectors:

- The automotive industry, primarily autocatalysis;
- Industrial applications (chemicals, electronics, glass, petroleum, medical/dental etc.);
- Jewellery; and

- Investment purposes.

Two of the four are technology driven and underpinned by the physical characteristics of the metals, viz. derived demand.

The largest consumer of PGMs is the automotive industry, primarily for use in auto catalysis. Critical consideration should thus be given to the likely evolution of transport technology in an increasingly energy constrained and environmentally conscious world.

Increased fuel cost and growing environmental consciousness is accelerating a move towards zero emissions objectives. Despite early challenges to the achievement of zero emissions, adoption of new technology will have an impact on PGM demand.

Current indications are that the technology evolution trajectory, for personal transportation needs currently met through motor vehicles with internal combustion engines, could be as follows:

- Hybrids;
- Plug-in hybrids;
- Hydrogen internal combustion engines;
- Battery electric; and
- Fuel cell electric.

Figure 9.2.1 indicates pertinent aspects relating to barriers to widespread adoption of these technologies and their likely impact on PGM consumption (after Anglo Platinum)

Technology	Description	Critical Barriers to Widespread Adoption	PGM Impact per unit
Hybrid	Internal combustion engine and electric motor(s) working together	• Barriers: Battery technology and battery weight • Investment: Led by auto manufacturers, uses advancements on current technologies	↔
Plug-in Hybrid	Battery Electric Car with back-up internal combustion engine	• Barriers: Battery technology, electrical requirements, lack of infrastructure • Investment: Led by auto manufacturers, uses advancements on current technologies	↔
Hydrogen Internal Combustion	Modified internal combustion engine using only hydrogen fuel	• Barriers: High cost, hydrogen production & storage • Investment: Led by auto manufacturers and government, uses advancements on current technologies	↘
Battery Electric	Electrical energy from on-board rechargeable battery	• Barriers: Battery technology, lack of infrastructure • Investment: Led by auto manufacturers and government	↘
Fuel Cell Electric	Onboard fuel cell creates electricity from hydrogen fuel and oxygen	• Barriers: Fuel cell technology, high cost, lack of required infrastructure, hydrogen production & storage • Investment: Led by auto manufacturers and government	↗

Source: EV World, Panel of California Air Resources Board. Notes: Fuel Cell Electric Hybrids included under Fuel Cell Electric.

Figure 9.2.1 Alternate technology to the internal combustion engine

The rate of adoption of these new technologies will largely be driven by the industrialised nations through emissions legislation. However over the next ten years it is probable that autocatalysts will continue to dominate emission control as new technologies are developed and implemented. During this period it is likely that:

- Thrifting and substitution will continue;
- New emission legislation, accelerated by environmental pressures and lobbying will support PGM loadings;
- Improved low emission solutions will be developed in combination with existing technologies;
- Developing economies will gain a larger share of the vehicle pool with emissions legislation lagging developed economies;
- Development of next generation technology will continue with little market penetration; and
- Vehicle pool changes will occur with higher proportion of smaller capacity vehicles.

The net outcome of this being robust demand for PGMs in the autocatalyst segment tempered by continued price-driven thrifting.

Over a longer period of ten to twenty five years there could be a significant move to lower emission vehicles and enabling investment in critical infrastructure. Under these circumstances it is possible that:

- There would be limited scope for further tightening of emission standards;
- Thrifting and platinum cannibalisation will continue, combined with further substitution outside PGMs;
- Improved low emission solutions would be developed in combination with existing technologies;
- Next generation technologies would gain a small share of the market driven by societal change and improved infrastructure;
- Large scale, government-led infrastructure investment would likely be a major factor in developing the most cost effective low emissions technology; and
- Smaller vehicles would become more dominant.

Under these circumstances there would be downward pressure on PGM demand owing to limited scope for tightening of emission standards and the dominance of smaller vehicles unless, there was widespread adoption of fuel cell based energy solutions.

Beyond the 25 year window it is inevitable that the next generation zero emission technologies gain significant market share as infrastructure development matches needs. Autocatalysis would thus be limited to specific approved applications with an upside potential for the widespread adoption of fuel cells as a primary energy source.

9.3 Economics

Global economic activity is the driver of consumption of product from the minerals and metal industry. Changes in economic activity have a direct and immediate impact on the industry as they impact demand and ultimately pricing. The most recent demonstration of this has been the global financial crisis of 2008/09.

During 2008 the global economy was severely impacted by a financial crisis that moved much of the industrialised world into a deep recession. On the first page of its "Declaration of the Summit on Financial Markets and the World Economy," dated 15 November 2008, leaders of the Group of 20 cited the following causes:

"*During a period of strong global growth, growing capital flows, and prolonged stability earlier this decade, market participants sought higher yields without an adequate appreciation of the risks and failed to exercise proper due diligence. At the same time, weak underwriting standards, unsound risk management practices, increasingly complex and opaque financial products, and consequent excessive leverage combined to create vulnerabilities in the system. Policy-makers, regulators and supervisors, in some advanced countries, did not adequately appreciate and address the risks building up in financial markets, keep pace with financial innovation, or take into account the systemic ramifications of domestic regulatory actions.*"

In essence the global financial crisis was triggered by the US sub-prime mortgage collapse which was characterised by a fall in U.S. housing prices, a rise in mortgage delinquencies and foreclosures, and severe disruption to the banking system, with major adverse consequences for the economies of the U.S. and Europe. When US house prices began falling in the second half of 2006, refinancing of adjustable-rate mortgages (loans to sub-prime borrowers) became more difficult. As these adjustable-rate mortgages began to reset at higher rates, mortgage delinquencies soared. Securities backed by subprime mortgages, widely held by financial firms, lost most of their value.

Global investors then drastically reduced purchases of riskier mortgage-backed debt and other securities. The result was a rapid decline in the capacity and willingness of the private financial system to support lending, tightening credit around the world and slowing economic growth in the US, Europe and the world.

The five largest U.S. investment banks, with combined liabilities or debts of $4 trillion, either went bankrupt (Lehman Brothers), were taken over by other companies (Bear Stearns and Merrill Lynch), or were bailed-out by the U.S. government (Goldman Sachs and Morgan Stanley) during 2008.

This coupled with the subsequent failure of several European banking and insurance institutions effectively halted global credit markets and forced unprecedented government interventions. Common measures included interest rate reductions, guaranteeing domestic bank deposits and inter- bank lending, providing financial bail outs to strategic companies to avoid large scale job losses, reducing company and personal taxes to stimulate spending and significant investment in infrastructure (e.g. China invested 7% of GDP on an infrastructure stimulus package).

The net effect of this crisis on the mineral industry has been:

- A marked drop off in metal prices (see Section 8.2.6);
- Reduced capital availability leading to the curtailment or deferral of projects; and
- Excessive levels of debt on mineral and metal company balance sheets leading to increased merger activity.

Subsequently recovery in the metal sector, following significant production cuts, has largely been driven by China. China has been the primary driver of metal prices this decade, as Chinese consumption of the main base metals (aluminium, copper, lead, nickel, tin and zinc) rose by 17% per year, while demand in the rest of the world actually fell 1.1% per year. In 2009, Chinese demand rose 23%, while demand in the world outside China fell 13.5%. Much of the rise in Chinese demand went into stocks (both private and government) but there was also strong stimulus-led consumption for construction and infrastructure.

Following the onset of the financial crisis in 2008, there were significant cutbacks at mines and smelters. With the sharp recovery in demand (mainly in China) prices more than doubled from their troughs in early 2009. Over the next two years, prices are not expected to rise substantially, partly given the large price appreciation to date, but mainly due to substantial idle capacity. Further large price increases would require idle capacity being reabsorbed over the longer-term, but with demand growth slowing towards trend, pressures for real price increases should be moderate. Over the longer term, declining ore grades, environmental and land rehabilitation, as well as water, energy and labour pressures may result in upward price pressure.

9.4 Contribution to the Conceptual Framework

Within the PGM industry the global business environment has greatest impact on strategic long term planning in the areas of:

- Emission standards: legislated emission standards currently underpin the demand for PGMs primarily for autocatalysis.
- Technology: changes in transportation technology will ultimately impact demand for PGMs as the world moves away from fossil fuel dependent internal combustion engines to zero emission technology.
- Global economy: demand for PGMs is inextricably linked to global economic activity.

The critical aspects of the global business environment must be incorporated into the strategic planning framework in order to align long term investment with probable market demand scenarios. This is done through integration of world views / scenarios, that adequately encapsulate the key global dimensions, into the planning process. See Section 11.4.

10 NATIONAL BUSINESS ENVIRONMENT

With reference to Figure 3.1 (schematic of key components of the conceptual framework), the national business environment is the final element in part A influencing the parameters considered during the generation of world views or scenarios as illustrated in part B of the same diagram. Consideration is given particularly to the impact of the legislative and policy environment.

10.1 Context

Following the democratic election of the ANC to government in 1994, South Africa has transitioned from the system of apartheid to one of majority rule. The new government embarked on the Reconstruction and Development Programme (RDP) to address the socio-economic consequences of apartheid, including alleviating poverty and addressing the massive shortfalls in social services across the country. A revised macro economic framework was articulated in 1996, the Growth, Employment and Redistribution strategy (GEAR). GEAR emphasised the pursuit of economic stability, market friendly policy and fiscal discipline as prerequisites for economic growth. A stable environment for private investment, the attraction of foreign investors, labour market flexibility, and sound industrial policy are policies that according to GEAR would create the potential for a faster growing economy with higher levels of employment.

Following the 2004 elections the government implemented programmes to sustain and speed up positive developments and address challenges through:

- Growing the economy as the main area of intervention;
- New measures to help the poor enter the economy so they could move out of poverty;
- Improving state performance;
- A campaign against crime; and
- Addressing South Africa’s relations with other countries.

Five government clusters were established to lead the changes:

- Governance and administration;
- Social;
- Economic;
- Justice, Crime Prevention and Security (JCPS); and
- International Relations, Peace and Security (IRPS).

The foundation established in the first decade and new initiatives since 2004 have enabled accelerated growth and development in South Africa. There are, however, still some challenges. The findings of the Policy co-ordination and Advisory services 15-Year review (Policy Co-ordination and Advisory Services: The Presidency, 2008) spell out the areas that require attention for South Africa going forward. These include:

- Speeding up growth and transforming the economy;
- Fighting poverty and building social cohesion;
- International co-operation; and
- Building an effective developmental state.

10.2 Legislative and policy environment

Within the context of the transition from apartheid through to a democratic society, legislation has become the key driver of sustainable change. The objective of this section is to highlight key legislation that impacts activities in the South African minerals industry. The information has been gathered from a wide range of sources with key emphasis on the Department of Mineral Resources (DMR – www.dmr.gov.za).

10.2.1 Introduction

The exploration for and subsequent exploitation of minerals in South Africa is subject to a wide range of legislation and regulation (see Table 10.2.1) however mineral asset acquisition and exploitation is primarily governed by the Minerals and Petroleum Resources Development Act, No. 28 of 2002 (MPRDA) and associated regulations.

The MPRDA, which came into effect on May 1, 2004, has redefined the regulatory framework for South Africa’s mining and minerals industry. The aim of the legislation is to correct historical imbalances in the industry without threatening overall attractiveness to both domestic and international investors. Prior to 2002 South African mineral rights were real rights held either by the State or the private sector (natural and juristic entities). Under the previous Act (Minerals Act, 50 of 1991) mineral rights could be severed from the ownership of land and registered separately. This dual ownership system represented an entry barrier to potential new investors owing to the complexity of linking surface right and mineral right ownership in logical units to allow viable exploitation of mineral rights. The objective of the MPRDA is for all mineral rights to be vested in the State, with due regard to constitutional ownership rights and security of tenure.

The MPRDA creates broader access to geological, geochemical and geophysical information, which, in the past, was held by the entity that conducted the exploration and was protected by restrictions on disclosure. Through this, and improved access to mineral rights, the Act is designed to bring an end to the situation in which a few large companies dominate South Africa's mining industry.

The intention of this development is to ensure increased access to mining activity for historically disadvantaged people, to stimulate the 'Junior' mining sector and to enable the State to terminate the practice of hoarding of mineral rights as a competitive barrier to entry, with a 'use-it-or-lose-it' principle. Under this approach if a company fails to use its mineral rights, under the agreed terms of use with the State, it is at risk of losing those rights.

10.2.2 The Minerals and Petroleum Resources Development Act

The Minerals and Petroleum Resources Development Act (MPRDA), No. 28 of 2002, under which the Broad-Based Socio-Economic Empowerment Charter for the South African mining industry was developed, was promulgated in May 2004. This Act replaces the Minerals Act, 50 of 1991 and regulates the prospecting for, and optimal exploitation, processing and utilisation of minerals; provides for safety and health in the mining industry; and controls the rehabilitation of land disturbed by exploration and mining.

The Act addresses many issues, including the following:

- Transformation of the minerals and mining industry;
- Promotion of equitable access to South Africa's mineral resources;
- Promotion of investment in exploration, mining and mineral beneficiation;
- Socio-economic development of South Africa; and
- Environmental sustainability of the mining industry.

The underlying objectives of the Act are to promote:

- Economic growth and resource development; and
- Empowerment of historically disadvantaged South Africans (HDSA).

The MPRDA includes a transition arrangement whereby old order mineral rights need to be converted to new order mineral rights. The relevant principals governing conversion of old order prospecting and mining rights are:

Prospecting Rights

- Old order prospecting rights remained in force until 30 April 2006.
- The holder of an old order prospecting right had the exclusive right to apply for conversion to a new order right.

- New order prospecting rights may be granted for a period not exceeding five years and may be renewed once, for a period not exceeding three years.
- Application for conversion of old order prospecting rights must have been received by May 2006.
- An environmental management plan must be included in an application.
- The application must be consistent with the objectives of the Act.

Mining Rights

- Old-order mining rights were given a five year transition window during which operations could continue.
- New order mining rights would be granted before May 2009.
- A mining right may be awarded for a period not greater than 30 years. There is no limit to the number of renewals, although each renewal period may not exceed 30 years.
- Applications for conversion had to include an environmental impact assessment and environmental management plan, and promote the objectives of the Act.

All new mining licences, including those for existing mineral rights properties, require evidence of a black economic empowerment plan, a social plan and an environmental management plan. The Act also requires that companies consult with government should they wish to beneficiate locally-produced minerals outside the country. This provision is designed to promote the use of mineral resources for sustainable economic development, and to avoid the trap that many developing countries fall into of exporting jobs through the exportation of un-beneficiated minerals. Based on this, the granting of mineral rights is influenced by the involvement of historically disadvantaged people, and by plans to beneficiate the minerals locally.

Under the MPRDA, a transitional period allowed existing holders of mineral and mining rights to convert their old order rights to new order rights. Mineral rights holders who did not hold prospecting permits or mining authorisations and who were not actively prospecting or mining on their properties were given a year from the date on which the Act came into effect to apply for prospecting or mining rights under the new legislation. Mineral rights holders who did not apply within this period lost their rights, and any other persons or groups were able to apply directly to the State for prospecting or mining rights for the areas formerly covered by those rights. Mineral rights holders who were actively prospecting or mining on the properties to which their old order rights related (with the necessary permits or authorisations from the DME) were given two and five years respectively, from the date on which the MPRDA came into effect, to convert their old order rights to new order prospecting or mining rights. The lengthy conversion process and subsequent legal conflicts arising from dual award of rights has been identified by some as causing widespread uncertainty among mining and exploration companies operating in South Africa.

10.2.3 Charters and Codes of Practice

Transformation charters are no more than evidence of a commitment to promote black economic empowerment (BEE) in a particular sector. Codes outrank Charters and must therefore be utilised as the principle tool for measuring BEE compliance (Department of Trade and Industry, [online]). However, the mining industry does not fall under the new Codes, released in February 2007. The tool for the mining industry remains the Mining Charter enacted in May 2004. The Mining Charter commitments include:

- Increased equity ownership by historically disadvantaged South Africans (HDSA) to 26% by 2014;
- Promotion of HDSA participation at all levels, especially management;
- Increased participation of women in the industry; and
- Support procurement from HDSA suppliers.

The development of the Charter was provided for in Section 100 of the Mineral and Petroleum Resources Development Bill, under the heading Transformation of the Industry, which stated that within six months of the Bill taking effect as an Act, the Minister of Mineral Resources was to have developed a Charter establishing the framework, targets and timetable for effecting the entry of historically disadvantaged South Africans into the mining industry. The Charter establishes how to achieve equitable access to South Africa’s mineral and petroleum resources for all South Africans, and outlines how the creation of employment and the advancement of social and economic welfare can take place through the appropriate use of these resources. The Charter also sets a framework that ensures that the holders of mining and production rights contribute towards the socioeconomic development of the areas in which they operate.

The broad-based socio-economic Charter sets out a clear scorecard for the mining industry. In terms of the MPRDA requirements for conversion of old order rights to new order rights; the Minister was required to take the entire scorecard into account upon adjudication of an application for conversion. The Mining Charter requires that 15% of the ownership of existing mining industry assets must be held by historically disadvantaged South Africans within five years, and 26% within ten years. First targets had to be met by 2009 and the full targets by 2014.

10.2.4 Royalties Bill

The Mineral and Petroleum Resources Royalty Bill (Royalty Bill) was introduced in October 2006 and sets royalties for the platinum industry at 3% and 6% of gross sales value for refined and unrefined PGM sales, respectively. Although some issues are not yet finalised, the Bill was due to come into effect in May 2009 and was subsequently postponed to 1 March 2010. The intent of the Royalty Bill is to promote the development of a local beneficiation industry.

10.2.5 Other legislation

The Promotion of Beneficiation Bill is expected to provide incentives for upstream companies that facilitate downstream investments, in order to reduce the exporting of unprocessed mineral products and to promote local value addition. The process of drafting this bill has been slowed in order to allow for greater engagement with industry, which seems opposed to the idea, claiming that it is not reasonable to expect those involved in primary extraction to get involved in beneficiation.

Although several other Acts govern the operations, support services, hospitals and every other conceivable aspect of the business (see Table 10.2.1) the impact of this legislation is largely tactical and it does not fundamentally impact the strategic direction of the business.

The MPRDA (section 37) also refers to the requirements of the National Environmental Management Act (NEMA) of 1998. The MPRDA stipulates that any prospecting or mining operation must be conducted within the generally accepted principles of sustainable development by integrating social, economic and environmental factors in planning and implementation. Approval of the environmental management plan that must include all aspects of rehabilitation, remediation and closure and the financial provision thereof is a requirement before any permits will be granted.

Table 10.2.1 Legislation applicable to mining and exploration activities in South Africa (after DME, SAMI, 2005/2006)

Area	Applicable Acts	Impacts
Industry: General administration of Minerals and Petroleum	Central Energy Fund Act, 1977 (58/1977) Precious Metal Act, 2005 (37/2005) Diamond Amendment Act, 2005 (29/2005) Mining Titles Registration Amendment Act, 2003 (24/2003) Mineral and Petroleum Resources Development Act (28/2002) National Nuclear Regulator Act, 1999 (47/1999) Nuclear Energy Act, 1999 (46/1999) Mine Health and Safety Act, 1996 (29/1996) Geoscience Act, 1993 (100/1993) Mineral Technology Act, 1989 (30/1989) Electricity Act, 1987 (41/1987) Diamonds Act, 1986 (56/1986) Petroleum Products Act, 1977 (120/1977) Mines And Works Act, 1956 (27/1956) (S 9)	
Environmental Management	Atmospheric Pollution Prevention Act Environment Conservation Act Gas Act Hazardous Substances Act National Environmental Management Act National Road Traffic Act National Roads Act National Water Act	Rehabilitation Remediation Classification of waste Handling of tailings Transport of concentrate, matte, crushed rock Transport , handling and disposal of waste
Mining Management	Explosives Act and Regulations Extension of Security of Tenure Act Land Reform Act Land Survey Act Mining Titles Registrations Act Precious Metals Act	Asset life Safety SAMREC & JORC
Project Management and Infrastructure	Water Services Act World Heritage Convention Act Electricity Act By-laws: varied	
Corporate Governance	South African Companies Act IFRS Income Tax Act Insider Trading Act Corporate Laws amendment Bill	Reporting requirements Auditing requirements King II Corporate Governance Sarbanes Oxley
Human Resources Management	Occupational Health and Safety Act Basic Conditions of Employment Act Labour Relations Act Compensation for Occupational Injuries and Diseases Act and Regulations Constitution of the Republic of south Africa Employment Equity Acts Mines Health and Safety Act Promotion of Equality and Prevention of Unfair Discrimination Act Skills Development Act and Regulations South African Qualifications Authority Act Skills Development Levies Act Unemployment Insurance act	Employee benefits Safety PPE Occupational Health issues
Health Care	Foodstuffs, Cosmetics and Disinfectants Act Health Act Medicines and Related Substances Act International Health Regulations Occupational Diseases in Mines and Works Act Occupational Health and Safety Act	Hospitals Hostels Canteens and food hygiene ARV programmes
Others	Fire Brigade Service Act	Asset life Safety

10.3 Contribution to the Conceptual Framework

The national business environment is dominated by a legislative environment which has been created to move South Africa from a racially biased society to a true democracy. The legislative environment is a key enabler of mining and business activities. Acquisition and effective exploitation of mineral assets is predicated on a well defined and effective system of legal tenure that will allow investment in long life assets.

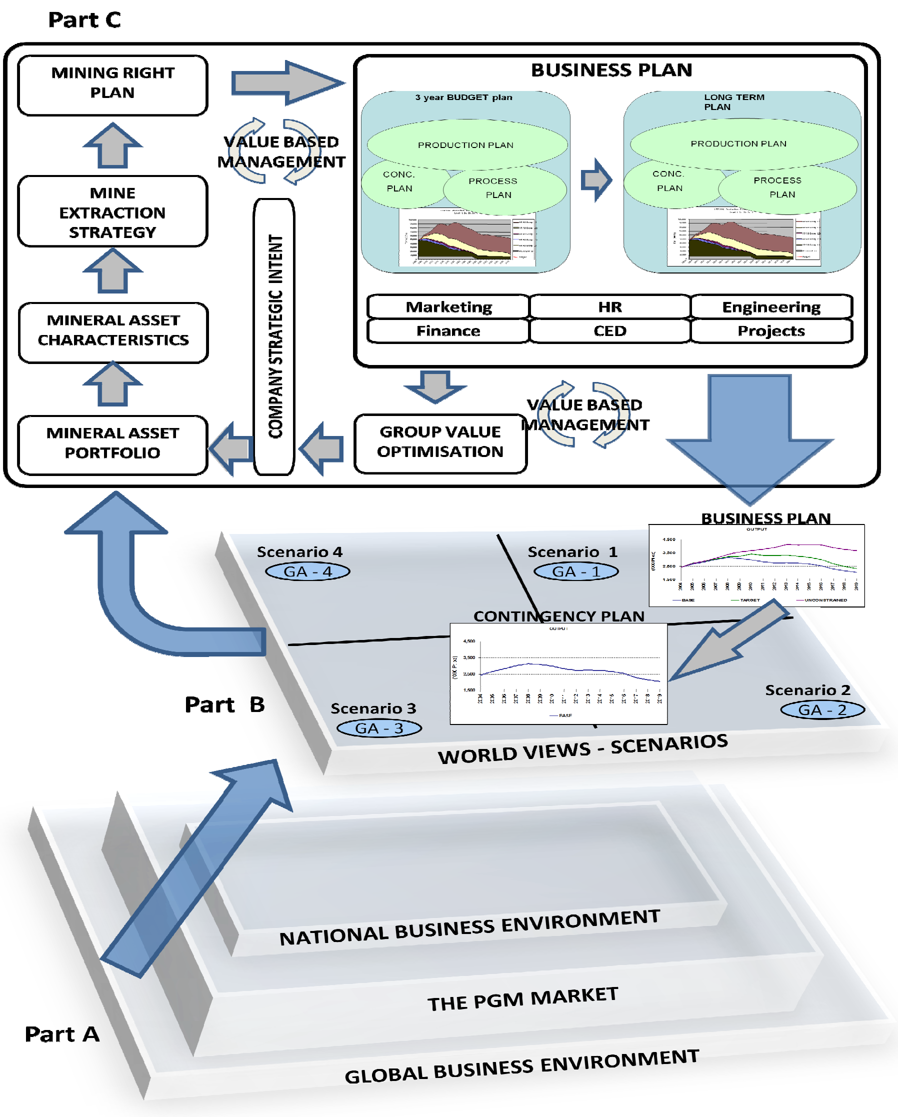
The exploration for and subsequent exploitation of minerals in South Africa is subject to a wide range of legislation and regulation, however mineral asset acquisition and exploitation is primarily governed by the Minerals and Petroleum Resources Development Act, No. 28 of 2002 (MPRDA) and associated regulations. The social licence to operate is further impacted by the Mining Charter.

Understanding and operating within the context of the legislation applicable to the minerals industry is requisite for effective business functioning and strategic long term planning.

11 THE STRATEGIC LONG TERM PLANNING (SLTP) CONCEPTUAL FRAMEWORK

The context (represented in part A of Figure 3.1 repeated below) in which world views or scenarios are developed and in which the planning process proceeds has been described in Chapters 6, 7, 8, 9 and 10. Chapter 11 describes and integrates the key components of the strategic long term planning conceptual framework: the development of scenarios or world views (represented in part B) and the business planning process (represented in part C).

As schematically indicated in Figure 3.1, repeated below, the process is iterative, with the business plan being dependent on the accepted, most likely world view, with fall back options being identified through real option valuation and contingency planning.



11.1 Introduction

Minerals and metal companies require mineral assets to generate value and attract investment (financial and social). Value generation from the mineral asset(s) is achieved through the application of a suitable business model.

Mineral resources are the underlying value construct of the mineral asset. The physical characteristics of a mineral resource such as type and nature of mineralisation, and physical structure (depth below surface, shape, extent, dip, surface topography, etc.) are fixed and do not change over time.

Mineral assets exist at a place (a specific fixed location) so defining a context (e.g. stakeholders, legal, social, environmental, infrastructural) that may change over time according to social and political evolution. This is the spatial context that encompasses location and associated operating environment.

The selection of a mineral asset portfolio is primarily affected, in the business context, by the perceived financial value (investment quantum, returns and duration), arising from the mineral asset(s). This value construct is primarily driven by the physical nature of the mineral resource (size, content and depth, which drive exploitation technology selection), the anticipated market demand for products arising from the mineral asset(s) and an accepted level of business risk in realising the perceived value. All of which, except the physical characteristics, are influenced by near term and forecast long term, economic and market variables.

The combination of the spatial context, economic, market and technical variables can be defined in a range of possible strategic scenarios or world views in which the value from the mineral asset(s) could be realised. The world view attempts to capture the interdependence and uncertainty associated with key elements of the spatial and business contexts across the long lead times associated with financial returns from mining activities.

Strategic long term planning of mineral and metal companies must therefore incorporate elements of:

- Optimisation of the mineral asset portfolio composition;
- A long term perspective of a possible business environment; and
- Flexibility of exploitation options in short term mine planning.

Within this context strategic long term planning therefore requires a cyclical reassessment of exploitation options (and the composition of the mineral asset portfolio), in the context of anticipated changes in the near and long term business operating environment. This results in a near term tactical response (typically in a budget period) and a longer term strategic response (the long term plan), both of which are encapsulated in the company business plan.

11.2 An overview of the strategic long term planning conceptual framework

As indicated in the introduction and repeated here, for a mining company to create sustainable value from mineral assets, it is necessary to:

- Optimise the composition of the mineral asset portfolio to align with strategic and business objectives;
- Create and operate long term assets within an anticipated long term business environment; and
- Create and retain flexibility in the short term tactical response allowing effective response to long term shifts in the business environment.

On this basis it is necessary to:

- Allow the fixed physical nature of the mineral asset(s) to drive definition of the optimal (lowest capital cost, lowest operating cost, highest efficiency, maximised cash flow) technical solution to mining and concentrating activities;
- Define and apply different business environment perspectives, world views or scenarios, to determine possible economic viability under the different perspectives, i.e. define the value proposition under different scenarios – what are the options?
- Develop and resource a portfolio of production entities from the mineral asset portfolio that creates flexibility to near and longer term business environment shifts, i.e. a production mix that allows variation of output (metals, operating cost, capital intensity) to respond to market demand and pricing.

This is the essence of the strategic long term planning conceptual framework with the interrelationships and nature of the overall framework schematically represented in Figure 3.1 and repeated at the beginning of this chapter.

Effective execution of these activities requires a structured, integrated approach across all elements of the business value chain from exploration through to product sales, allowing cyclical (typically annual) reassessment and adjustment. Integral to this is a common language, standards, systems and processes to align decisions and actions across the organisation and over time. These requirements are met through the application of a series of tools and processes within a planning cycle that defines strategic long term planning and leads to mineral portfolio asset optimisation.

These comprise:

- Business strategy definition;
- Scenario planning (world views);
- Definition of long term planning parameters (global assumptions);
- Business value optimisation (value based management for identification and choice of business model options);
- Long term planning procedures (planning cycle, mine extraction strategies, mining right plans, long term plans);
- Capital investment prioritisation, real option analysis and project value tracking;
- Definition of the long term plan and business plan;
- Definition of upside or downside responses (contingency plan); and
- Execution plans for supporting capability:
    - Project portfolio execution;
    - Metallurgical process capacity (smelting, refining ,effluent);
    - Infrastructure (water, electricity, roads, rail, housing);
    - People (skills, motivation, organisational culture); and
    - Community (stakeholder alignment and participation).

Each of these activities is considered in the following sections of Chapter 11. It is important to note that activities are not necessarily sequential, as feedback loops occur between different activities at different points in the planning cycle.

11.3 Business strategy definition

Overall company strategy, as defined and communicated by the board directs the execution of the business objectives and provides the framework for decision making. This is the starting point for strategic long term planning for metals and minerals entities.

The processes associated with definition of overall company strategy are excluded from the scope of this work; however it is pertinent to note that the core outputs of the strategic long term planning process are also critical inputs into the overall company strategic planning process.

Typically company strategic planning follows elements of:

- Information gathering and analysis (internal, external, market);
- Identification of critical issues facing the organisation;
- Development of a strategic vision statement that sets future direction;
- Mission statement review/revision;
- Development of strategic goals;
- Formulation of strategies for each goal; and
- Preparation for operational planning based on the strategic plan.

In the strategic long term planning approach, the company strategy directs the objectives of value based management and defines prioritisation logic in the long term planning process, i.e. the overall mineral asset portfolio optimisation process is directed by the company strategic intent.

Conversely the global and local context along with the developed world views influence company strategy as part of the information gathering and analysis processes, in the overall strategic planning for the business. Similarly, the real option analysis of the value of possible trajectories / exploitation choices for the business, comprise inputs to the aspect of identification of critical issues facing the organisation.

11.4 Scenarios or world views

This section introduces and defines the link between long term planning parameters (global assumptions) and possible future world views as conceived in scenario planning.

11.4.1 Introduction

Developing an understanding of the uncertainty inherent in the external and future environments and testing the robustness of strategic plans against a set of possible futures, is a critical component of strategic long term planning. The reality of the business environment is that it is increasingly complex and dynamic. Analysing key global trends and seeking to influence the possible business future(s), requires a widening of perspective to a range of possibilities.

In the strategic evaluation of mineral asset exploitation options, a view must be taken of possible future(s) and associated parameters that will influence investment decisions.

This view, which is encapsulated in a set of common long term planning parameters (the global assumptions), can and does change in line with macro-economic drivers. Whilst a project development and execution team correctly focuses on ways to mitigate risks associated with local assumptions (project specific, technical uncertainties), it is imperative that strategic decision makers are aware of, and understand the significance of global assumptions that have a bearing not only on specific project investments, but rather the entire portfolio of mineral assets held by the business.

The complexity of long term planning parameters (typically forecasts of exchange rates, inflation rates, metal prices, cost escalations, capital escalations, working capital, etc.) and the relationships between them and events that occur in the global economy require that inherent uncertainty in investment decision making and portfolio planning is communicated through scenario planning.

11.4.2 Scenario planning

The concept of scenarios and scenario planning is well established in human history. As a strategic planning tool, scenario planning is rooted in military strategies, in the form of war game simulations (Brown, 1968). Although scenario techniques have a long history, their application in strategic planning in the business context is a relatively new phenomenon (Bradfield *et al,* 2005).

Scenario planning can be described in terms of:

- An internally consistent view of what the future might turn out to be – not a forecast, but one possible future outcome, (Porter, 1985);
- That part of strategic planning which relates to the tools and technologies for managing the uncertainties of the future, (Schwartz, 1996);
- Stories describing plausible futures that are developed using methods that systematically gather perceptions about certainties and uncertainties, (Selin, 2006); or
- Narrative stories that follow particular paths into the future, (Kortea and Chermack, 2007).

According to van der Heijden *et al.* (2002), scenario work can either serve specific once-off content needs, or an on-going general process aimed at longer-term survival capability; and /or the work can be undertaken either to open up an organisational mind for exploration, or to achieve closure on specific decisions and actions. However, being explicit about the purpose of the scenario development is critical to ensure logic alignment. Van der Heijden *et al.* (2002), indentified four main areas of purpose in scenario work: making sense of particularly puzzling situations; developing strategy; anticipation; and adaptive organisational learning as indicated in Table11.4.1

Table 11.4.1 Scenario planning – areas of purpose (after van der Heijden *et al*, 2002)

		Comment
Making Sense	Thinking–Content	The aim is to acquire new understanding of aspects of the environment. The scenario exercise helps in defining the key research questions, a key requirement in generating new understanding and possible new action. Examples where scenarios helped define the important questions are Pierre Wack's original oil price scenarios and the Mont Fleur South African project (van der Heijden *at el*., 2002 and Kahane, 1991).
Developing an Optimal Strategy	Action–Content	The aim here is to develop a preferred strategy. According to van der Heijden *at el.,* (2002), most failures are here, because strategic options are generated as part of single cycle scenario process. Van der Heijden *at el.,* (2002), have concluded that stand-alone scenario projects aiming for a deliverable of a specific optimal strategy that changes the strategic direction of the business are difficult to turn into a success.
Anticipation	Thinking–Process	The aim is to enhance the quality of the ongoing multi-level strategic conversations. The purpose according to van der Heijden *at el.,* (2002) is to enhance the shared understanding of the macro-economic and business environment, and thereby of the anticipatory capacity of the organisation.
Adaptive Organisational Learning	Action – Process	They aim to motivate the organisation to engage in new actions - action-based organisational learning, that will make the organisation aware of new options, of what works and what does not. Organisational learning is an action-driven way of learning from experience how to navigate the business environment (van der Heijden *at el.,* 2002).

11.4.3 Uncertainty and complexity

Uncertainty means opportunities. How does an organisation find its way in an environment full of uncertainty? Exploring uncertainty, allows an organisation to indentify points of familiarity when moving towards the future. The future is uncertain and any form of prediction and forecasting could be wrong. Without futuristic work geared towards unpacking uncertainty, how do you decide on the next move? The process of building new understanding through scenario planning and other futuristic methodologies becomes critical in this process. This allows the organisation to engage in a process of learning.

Using uncertain futures in strategic conversations through scenario planning seems a practical way of managing rationalist assumptions (van der Heijden, 2004). This is acceptable based on the rationale that the future is uncertain and considering multiple futures ring fences this uncertainty.

11.4.4 Application – workshop methodology

The development, socialisation and adoption of common world views can be facilitated through a workshop process where scenarios are created as a way of presenting alternate future world views, and from which critical long term planning parameters can be developed.

Developing an understanding of the uncertainty inherent in the external and future environments and testing the robustness of any strategic plans against a set of possible futures, is a critical component of long-term and strategic planning. For most companies, the reality is that the business environment is increasingly complex and changing. Analysing key global trends and seeking to influence the future(s), requires opening our minds to a range of possibilities and discontinuities. The complexity of strategic problems and the need to find acceptable solutions requires using methodologies that are innovative, rigorous and participatory.

A means to developing and understanding the implications for the business is through developing scenarios.

Typically the objectives of scenario planning workshops are to:

- Stimulate imaginative dialogue about the future to better prepare for the kind of challenges that may lie ahead;
- Anticipate circumstances and explore possible outcomes;
- Develop a platform that can be used to pressure test the business strategy; and
- Enhance the strategic planning learning process.

Approach and key questions

Strategic conversations seek to address the following fundamental questions about the future of the industry:

- What will be the needs, choices and possibilities that will shape the global ‘platinum system’?
- How will the ‘platinum system’ look in the next three, 15 years and beyond?
- What roles will competitors, government, society, employees and different components of the organisation play in shaping this ‘system’?

The sessions should be facilitated by an external person with little specific knowledge of the platinum industry in order to avoid entrenchment of ‘accepted truths’. However the strategic conversation teams should comprise people with expert knowledge of the platinum industry and global economics. Typically the participants would cover internal roles across the value chain such as , mineral resource management, strategy, planning, economics, sustainable development, supply chain, marketing, legal, government liaison, corporate finance, mining and metallurgical process.

Process, critical steps and timelines

Key elements of this process comprise:

- Learning process: to understand the methodology, theory and set the context;
- Scope definition: Global, 15 years and beyond;
- Determination of the key variables and drivers e.g. demographics; innovation, science and technology; geopolitical relations and the role of China; the global economy and globalisation; natural resources and the environment;
- Exploring key themes (e.g. PGM demand, society issues–social licence to operate, Government issues, environmental issues, technology and alternative applications, capital and operating cost escalators, competitor actions, etc.); aimed at raising key drivers, key questions and setting the context;
- Developing scenario themes and storylines;
- Writing up the synthesis and scenarios; and
- Reviews of the outputs.

Outputs and deliverables

The main deliverables are:

- A common view of inputs to the strategic planning process;
- A synthesis report on the outcomes of the exercise and views about the future;
- Group learning;

- A baseline for future related work; and
- A repository of information about the scenario planning methodology.

11.4.5 Contribution to the Conceptual Framework

The scenarios or world views developed through this process inform the development of long term planning parameters (the global assumptions) to be applied throughout the strategic long term planning process. These scenarios or world views create the critical link between the market, the global and national business environments and the utilisation of the mineral asset portfolio.

Dependent on the number of scenarios developed (typically three, maximum four) alternate business options can then be developed with identification of suitable trajectories between scenarios, depending on changing circumstances or progression between scenarios over time.

These changing trajectories are reflected in the contingency planning logic (see Section 11.8) and provide the basis for real option valuations (see Section 11.9).

The critical difference in approach is rational movement towards an identified and agreed world view (previously established through the scenario development process) rather than an ad-hoc crisis driven response. The organisation knows what trajectory to follow as the contingency positions have been previously defined.

11.5 Global assumption (GA) methodology

Cash flow estimates used in discounted cash flow analyses are fundamentally derived from estimates of revenue, operating cost and capital cost. Extensive effort is directed at estimating costs (both operating and capital) to accuracy levels of <10% error during the feasibility studies. Similarly production, grade and metallurgical recoveries are estimated at comparable levels of accuracy to drive the revenue line.

However an area which is often not subject to the same rigour is the impact on plan viability of assumptions regarding metal (commodity) prices, exchange rates, inflation rates (domestic and foreign), and escalation factors (capital expenditure and operating expenditure) factors.

On the assumption that these global parameters are usually rigorously determined for a five year period and then maintained at long term trend estimates, the adoption of an optimistic or pessimistic long term perspective can have a significant effect on projects with 15 - 30 year life spans. The risk of not undertaking viable projects because of a pessimistic long term view or conversely undertaking marginal projects because of an optimistic long term view is mitigated through the use of scenarios or world views plus real option valuations. Estimation of these long term planning parameters in the context of anticipated business world views or scenarios is therefore critical.

Global assumptions are a set of long term planning and economic parameters that best encapsulate the external drivers of value in the exploitation of platinum group metals. In a sense, the aggregated parameters provide a descriptor of a current and future world view and transition between the two. When investment decisions are made in the context of these global assumptions, these decisions are positioned with the expectation that this future world view will evolve.

11.5.1 The context in which mining investment decisions are made

Directors, executives and strategic planners all have a fiduciary responsibility for oversight in the organisation (Taylor *et al*, 2006). This entails identifying, evaluating and managing risks and uncertainties that the organisation may encounter. The ability to manage short term risks to stabilise earnings and long term risks to ensure viability of the business is critical. In respect of major investment decisions in the complex platinum industry, this can be daunting. The contexts within which such decisions are made are two-fold.

Firstly, decision makers have to contend with project uncertainty defined by project specific parameters, the local assumptions. Typically, for minerals projects these are mineral resource (e.g. size, delineation, grade), mining method and efficiencies, processing method and efficiencies, project ramp-up rate, initial capital requirements and operating costs. Getting this right is about committing to and implementing a competitive strategy – what needs to be done and how it should be done is clear. However investment decisions are also about other uncertainties, primarily the business environment in which the project will operate ten or more years hence, following the initial capital investment. In this context, decision makers need to develop foresight to consider future circumstances and how these might impact the organisation (Taylor and Leggio, 2003), and the investment made to date. This is where the value of a well structured set of global assumptions is realised.

11.5.2 Global assumptions – key drivers of future value estimates

A critical step in understanding the future is an understanding of the key drivers that determine future developments (Postma and Liebl, 2005). These so called driving forces or causal factors are many and are often complex in their relationships. The interrelationship of these driving forces or casual factors for the platinum industry is indicated, schematically, in Figure 11.5.1 which highlights elements of complexity and interdependency.

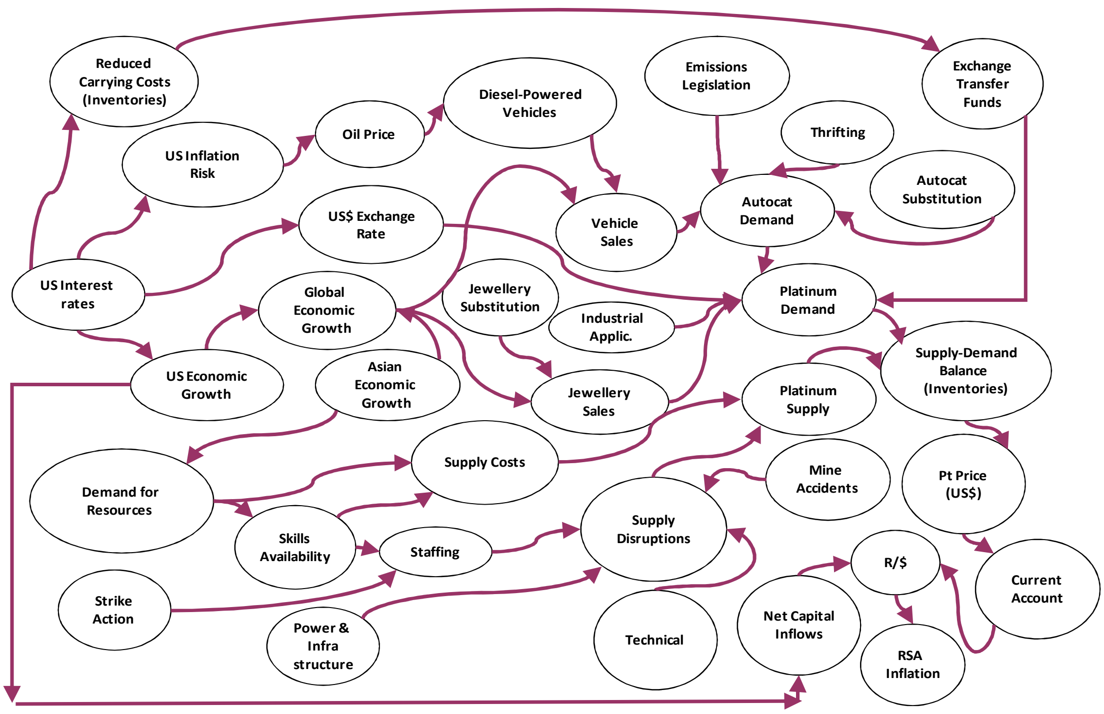


Figure 11.5.1 Schematic depiction of key drivers or causal factors of change, their relationships and complexity, in the platinum mining industry

A useful framework in simplifying them is to classify these factors as either constant, predetermined or uncertain (Porter, 1985). *Constant* factors are those structural factors that are unlikely to change. Factors that are fairly predictable and can be forecast with reasonable accuracy are classified as *predetermined*. Both their outcome and their probabilities are known. Schwartz (1996) best describes these factors as either slowly moving trends or a result of constrained situations. *Uncertainties* are those factors whose outcomes are known, but their probabilities are not, Taylor *et al.* (2006), propose a similar framework, using the terms known (predictable) and unknown (uncertainties), and extend the definition to include the "unknowable".

The relationships in Figure 11.5.1 can be rearranged, as in Figure 11.5.2, whereby the key uncertainties are located at the outermost sphere, their determination being based on a possible future world view (a scenario). These less predictable factors (unknowns /

uncertainties) are used to infer the parameters in the next inner shell, which in turn influence the parameters in the core sphere. The logic being that once a view of the outermost parameters has been established (from a scenario), the parameters of the inner shells can be progressively inferred creating a consistency in the parameter logic that is driven by the possible future world view.

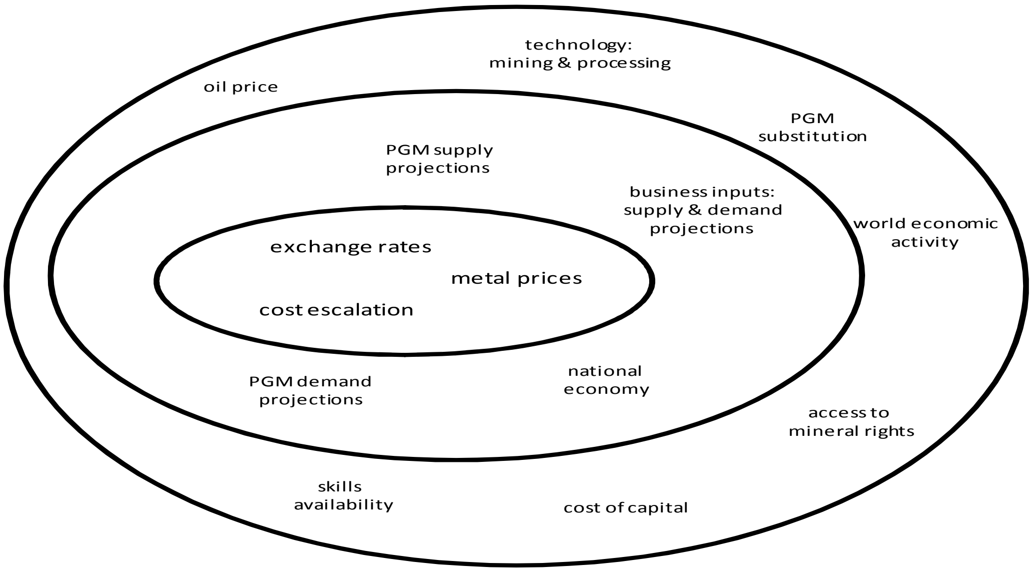


Figure 11.5.2 Simplified depiction of key drivers or causal-effect factors of change in the platinum mining industry

This framework provides guidance as to which parameters ought to constitute the global assumptions, keeping in mind the purpose of the global assumptions is to create a link between the vagaries of a possible future world and actual parameters that are quantified for investment analysis. In this context the development of alternate global assumptions to align with alternate future world views is not so much a forecasting exercise, but more a means of understanding the implications of uncertainty and facilitating the testing of investment decisions in the context of future uncertainties. Consistency in the logic of generation of parameters associated with alternate future world views is therefore paramount.

Table 11.5.1 summarises the core parameters that currently comprise global assumptions considered as applicable to the South African platinum mining industry.

Table 11.5.1 Global assumption parameters

Economic	Fiscal	Revenue	Costs	Technological
US CPI RSA CPI R/US$	Income taxation Secondary taxation on companies Royalties	PGM prices Base metal prices Other metal prices Working capital factors	Capital expenditure Capital escalation Operating cost escalation	Smelter recoveries Refinery recoveries Metal pipelines

11.5.3 Derivation process

Derivation of the specific global assumptions associated with each scenario is normally conducted separately to the scenario development process. Various technical experts are identified (internal and external to the organisation) from different disciplines (economics, marketing, finance, supply chain, capital projects, estimators, etc.) and presented with the scenarios with a request for relevant inputs. In some instances, certain parameters become inputs to other parameters. For example, the view on GDP and inflation is used as input into the expert opinion regarding cost escalation. On collation, the global assumptions are circulated within the same expert group for final comment and alignment as necessary. This approach creates better understanding of parameter interdependency and clarity on the scenario structure, whilst testing internal consistencies. An example of the scenario to global assumption linkage is indicated in Table 11.5.2

Within this approach the following logic applies:

- The cost escalations and demand environment will be driven by descriptors within each scenario.
- The metal price forecast is triangulated using cost margins, incentive prices and analysts views.
- Long term prices will trend to a flat, real money terms, long term price, when supply and demand are in balance.

Table 11.5.2 Example – linkage of global parameters to world views

	KEY DRIVING FORCES	Low Economic Growth & Low PGM Demand	High PGM Demand amidst Global Economic slowdown	Low PGM demand & High Economic growth	High PGM Demand & High Economic Growth
Global Economic Drivers	World GDP (CAGR : 2008-2018) - Profile over time	2.7%	2.7%	3.4%	3.4%
	Pt Demand Growth (CAGR: 2008-2018) - Profile over time	3.5%	4.5%	3.5%	4.5%
	US Dollar over time	Weak US$	Weak US$	Unchanged from Real 2005	Unchanged from Real 2005
	US Interest Rates (Profile over time)	Low	Low	Higher	Higher
	Inflation Rates (Profile over time)	High	High	Low	Low
	Energy Costs (Oil, Brent) - Real 2008 US$/barrel - Profile over time	100	100	70	70
	Supply-Demand Balance (Inventories) over time	Supply surplus	Supply deficit	Supply surplus	Supply deficit
PGM Demand Drivers	Substitution	Available and in high usage	No substitution, Pt success in Fuel Cell Technology	Available and high usage	No substitution, Pt success in Fuel Cell Technology
	Thrifting	Not applicable, as cheaper substitutes are available	Not applicable	Not applicable	Not applicable
	Enviromental thrust for more stringent legislation	No legislation(?)	Stringent legislation	Stringent legislation	Stringent legislation
PGM Supply Drivers	Supply Disruptions & Constraints	Infrastructure constrained, terse relationship with labour & govt.	None	Infrastructure constrained (power, water)	Limited, as constraints are overcome through Chinese import
	Supply Costs (opex, capex)	Cost escalations are very high	Low escalations due to high availability	Cost escalations are high	High
	Skills & Labour Availability	Readily available	Readily available	Low availability due to high economic growth environment	Readily available Chinese labour at lower cost

11.5.4 Global assumptions and scenarios – link into planning process

The strategic long term planning process at Anglo Platinum has been described previously (Smith *et al,* 2006a, 2006b, 2007, Andersen *et al*, 2005). Enhancements to the process with respect to incorporating uncertainty comprise:

- Inclusion of scenarios in the strategic directive provided to the operation in the development of the mine extraction strategy;
- Provision for alternate mining right plans by scenario, if warranted; and
- That the strategic long term plans for each mining right area incorporate contingency plans aligned with agreed scenarios.

Although this enhancement requires additional effort, it does allow the development of contingency responses that are aligned with possible future world views and so creates robustness to the planning of long life, long lead time mining assets.

The final result of the application of scenarios in the long term planning context is to arrive at a set of possible alternate production profiles based on anticipated scenarios / world views. These are essentially contingency plans per world view and can be schematically represented as per Figure 11.5.3, where each scenario or world view comprises three profiles.

These are the *mine extraction strategy (MES) profile* which represents the unconstrained production profile (unchanged between scenarios) that assumes implementation of all possible projects within a mining right area portfolio, the *target or business plan* profile that matches the optimal production level, as defined by the constraints applied and associated global assumptions for each scenario, and the *contingency plan* profile which represents the value maximised fallback position from the business plan, based on a move to a less favourable scenario. Optimisation of all profiles in each scenario is driven by value maximisation principles.

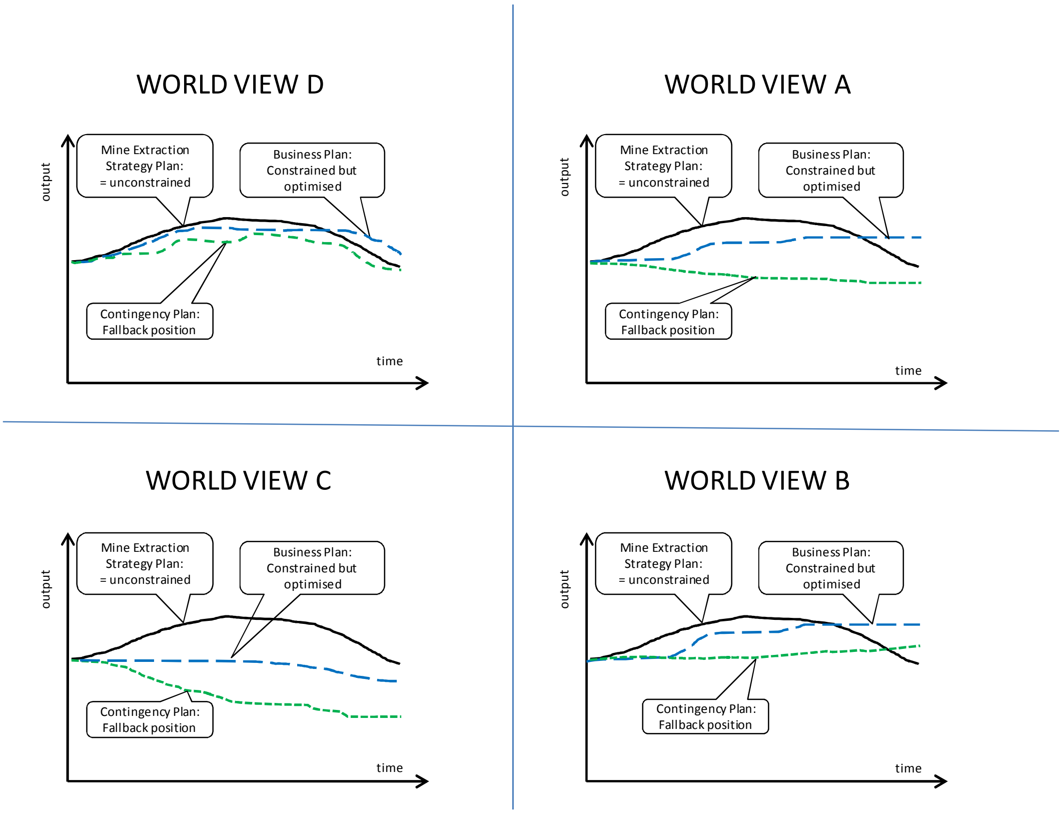


Figure 11.5.3 Schematic presentation of alternate production profiles aggregated from each scenario

The ability of such a representation to convey to decision makers the impact that future world views may have on the growth of the organisation is powerful.

The ability to realise future value is dependent on developing an understanding of possible future world views in which the business could operate. This is the critical function of scenario planning within the strategic mine planning domain – the development of alternate production portfolios, from the same mineral resource, that are consistent with plausible future scenarios in which the business may find itself.

These world views are developed using a scenario planning methodology, and are interpreted into a set of long term planning parameters called the global assumptions. These global assumptions are the basis for the formulation of alternate project portfolios, and provide a mechanism through which executive action can initiate a series of actions for risk mitigation and contingency planning, whilst retaining flexibility to maximise value.

11.5.5 Determination of long term economic and planning parameters – the global assumptions

The global assumptions are a set of long term economic and planning parameters that are applied uniformly across the organisation for planning and valuation purposes. No other use of planning or modelling parameters is permitted except that of the global assumptions.

It is important to note that the definition of the global assumptions is greater than simply metal prices and exchange rates, as consideration is given to:

- Inflation (USA and SA);
- Cost escalators (capex, on-mine and off-mine operating costs);
- Exchange rates;
- Tax regime;
- Metal prices;
- Commissions and discounts;
- Metal pipeline;
- Off-mine costs (smelting, refining, metal transport, other);
- Smelting and refining recoveries; and
- Working capital factors.

The long term economic and planning parameters (global assumptions) are assembled and issued, four times a year, characterised as follows:

- First quarter – Update of money terms for previous year Q4 data;
- Second quarter – Full analysis and metal pricing forum input. This dataset is core to the long term planning process, strategy development and ultimately the mineral resource to reserve conversion process;
- Third quarter – Incorporation of budget parameters for the first three years – forward price analysis (years one to three), adjust year four to long term commencement in year six; and
- Fourth quarter –Update of forward prices, long term price.

Note: The economic and planning parameters are kept constant (in real terms for financial parameters) beyond five years of forecast.

The logic applied in the estimation of long-term PGM prices, based on a world view as developed in Section 11.4, is indicated in the schematic in Figure 11.5.4.

- A view is taken of the forecast economic environment, and its associated economic parameters (cost escalation, consumer price index - CPI, exchange rates, etc.) This is the world view developed from scenario planning.
- A demand forecast is made based on market research and expectations. Production of current operating mines is forecast, and a supply deficit (or surplus) is estimated.
- Assuming a supply gap exists, a portfolio of new projects is formulated to fill the supply gap and achieve a compound annual growth rate in production to meet the anticipated market status in the world view. An incentive price is determined that would be required to bring the portfolio of projects into production. Similarly a floor price (marginal producer price) is determined.

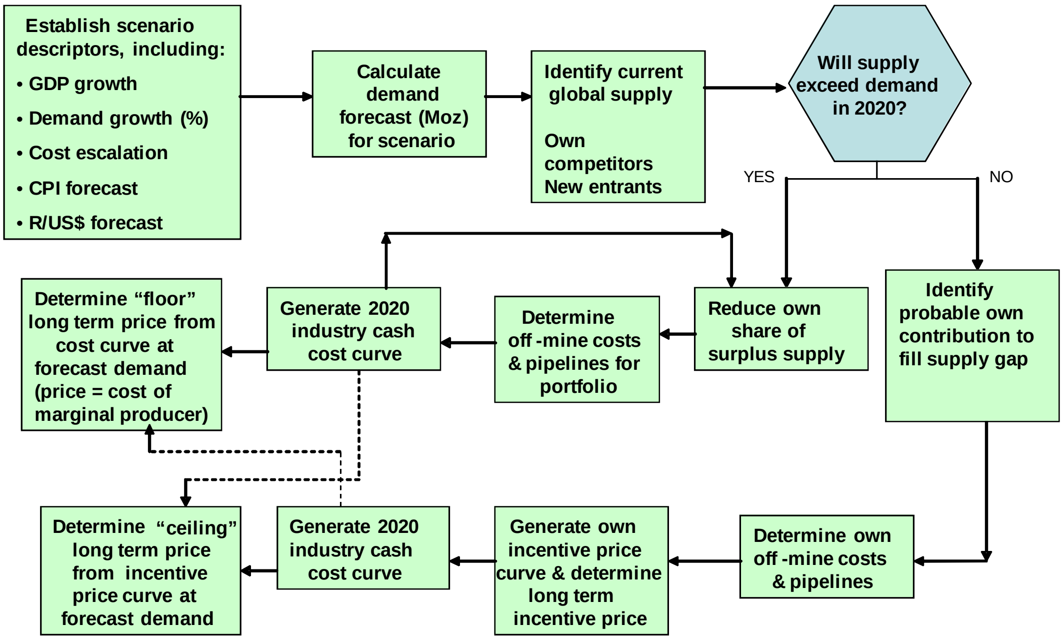


Figure 11.5.4 Long term metal price estimation based on forecast supply and demand

The key drivers in price determination are considered to be:

- Global supply/demand balance;
- Operating cost;
- Operating and capital cost escalators;
- Metal pipelines and recoveries;
- R/US$ exchange rates;
- Project capital and production schedules; and
- Infrastructure capital requirements.

The business production portfolio should be determined by a view, based on an accepted scenario, of a likely supply surplus or deficit over a time span of at least ten years. Given the information on current supply, including that of competitors, as well as probable competitor projects in their respective pipelines, a target portfolio is determined that would best enable a supply-demand balance in the long term, as represented schematically in Figure 11.5.5. It is important to note that Figure 11.5.5 represents a view taken in early 2007 prior to the global financial crisis of 2008.

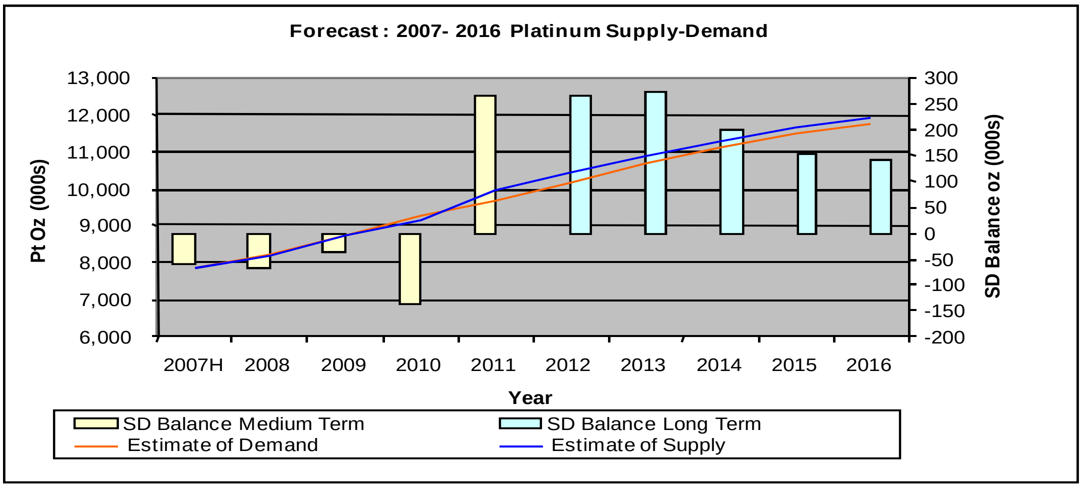


Figure 11.5.5 Target scenario – supply / demand and growth estimates

Operating cost escalation rates are derived for on-mine operating costs and off-mine operating costs (process division costs). Operating cost escalation rates are derived by applying the projected budget cost increases for labour, utilities, stores and other costs to the actual breakdown (historic and forecast) of operating costs into these cost elements.

Capital escalation factors are externally sourced from appropriate industry entities and aligned with anticipated spend by major project component category.

Process recoveries, pipelines and unit operating costs are generated by the Process Division (smelters, base metal refinery and precious metal refinery) on the basis of throughput and process technology modifications reflected in the approved planning scenario. Unit costs are expressed as R/t smelted, R/t refined base metals (Ni & Cu only) and R/oz refined PGM 4E.

Off mine costs are a category of costs that include the following:

- Smelting costs;
- Base metals refining costs;
- Precious metals refining costs;
- Base metals transport costs;
- Precious metals transport costs; and
- Other costs (R&D, etc.).

Smelting unit costs are derived from fixed and variable budget operating costs for both smelting and converting activities supplied by the Process Division Finance Department.

The percentage fixed costs for smelting and converting are allocated per major cost centre (e.g. labour, stores, utilities, contractors, sundry, total indirect). The percentage fixed costs for smelting and converting are applied to three year budget operating costs and forecast throughput (as per the approved SLTP scenario) in terms of concentrate smelted and converter matte produced for the various smelting and converting unit operations, including the total indirect costs, to calculate the variable and fixed costs to be applied in the planning parameters estimation process. Fixed/variable cost ratios are reviewed and updated annually. Once variable costs have been derived, the final variable cost is calculated net of the smelting by-product (sulphuric acid). Finally smelting fixed and variable costs are applied to the forecast concentrate tonnage to calculate overall smelting average unit costs (R/ton smelted).

The estimation of base metal refining unit costs should be based on existing installed capacity, forecast expansions and any tolling requirement. Hence base metal refining unit costs are derived from a combination of both base metal refinery operating costs, based on fixed and variable budget operating costs, and toll refining costs based on indicative terms received from tolling companies. This approach must be reviewed annually based on anticipated nickel processing capacity. Fixed/variable cost ratios are reviewed and updated annually. Once variable costs have been derived, a final variable cost is calculated net of base metal refining by-product credit. Finally base metal refining fixed, variable and toll refining costs are applied to the forecast concentrate tonnage to calculate overall base metal refining average unit costs.

As with smelting, precious metal refining (PMR) unit costs are derived from fixed and variable budget operating costs for PMR supplied by the Process Division. The percentage fixed costs are applied to three year budget operating costs and forecast throughput in terms of concentrate smelted and converter matte produced for the PMR unit operation, to calculate variable and fixed costs to be applied in the SLTP global assumption estimation process. Treatment charges and refining costs associated with other PGM residues produced within Process Division, along with refining charges associated with gold produced at the PMR are included in the overall PMR costs. Overall PMR costs, fixed and variable are applied to the forecast concentrate tonnage to calculate overall PMR average unit costs.

Precious metal transport costs are analysed from the latest available budget and expressed as R/oz PGM 4E. Base metal transport costs are based on the latest projected Ni, Cu and Co production for the latest SLTP. In addition the base metal transport costs are analysed from the latest available budget and expressed as R/t base metal (Ni and Cu). Other off-mine costs are analysed from the latest available budget to include all other operating costs not captured elsewhere (most importantly jewellery, exploration, marketing and precious metal treatment costs).

Metal pipelines and recoveries information is sourced from the Process Division, and is based on actual data and latest estimates.

R/US$ exchange rate (and other exchange rates as and when required), USCPI and SACPI projections are sourced from external expert entities. At the time of the final budget plan preparation, the economic parameters used in the budget are incorporated into the first three years of the long term planning parameters. This aligns the planning parameters with the final budget parameters. Step changes in R/$ exchange rates are avoided with 'smoothing' being permitted post the three year budget period to effect a smooth transition to the forecast long term real exchange rate.

Project costs and production schedules are determined for each project as outlined in project valuation procedures. Capital costs for infrastructure are identified and allocated to individual projects.

11.5.6 Metal price – forecasting

In order to build shared understanding of the logic and drivers of metal prices included in the long term planning parameters (global assumptions) a grouping of senior executives (termed the metal pricing forum) chaired by the CEO, meets two or three times per year to agree on metal prices and exchange rates, associated with each scenario, to be applied in the strategic planning process.

The scope of metal prices and the price path considered comprises short term, mid-term and long term prices. Short-term refers to the immediate three years, viz. the current year plus two years forward, regarded largely as the budget period. The period between four and six years is referred to as the mid-term, while the long term period is regarded as the time beyond six years.

As platinum mining does present with more than just the platinum metal, metals pricing includes the following:

- Platinum group metals (PGMs) – platinum, palladium, rhodium, iridium, ruthenium;
- Gold; and
- Base metals – nickel, copper, cobalt.

Iridium and ruthenium revenues are generally not included in investment analyses as demand for these metals is volatile and unpredictable. As there is no stable significant demand, they do not generate consistent revenues that can be reliably applied to the business case for mining projects. Hence their prices are used only for sensitivity analyses.

Gold is an important by-metal from platinum mines with forecast prices being based on the outlook of external experts. As with gold; nickel and copper prices are adopted from results presented by third parties, with a range of consensus exercises being conducted. The long term cobalt price is subject to contractual off take. As and when these contracts are re-negotiated, the prices are adjusted accordingly.

Metal pricing information and assumptions are presented to a metal pricing forum for ratification prior to utilisation in global assumptions. Information presented to the metal pricing forum for discussion comprises:

- A market perspective of long and short term metal price forecasts: These are compiled from public domain information (normally banks and investment analysts).
- An investment break-even price based on a supply portfolio that will sustain a balanced market: This estimate would be based on historic pricing sensitivity and provides a long term price estimate based on the growth / contraction of the market world view.
- Short term (less than 24 months) budget pricing: This is a short term price which relates to forward price curves.
- Commissioned third party views, e.g. Johnson Matthey, and SFA Oxford – short and long term.

The process undertaken in the metal pricing forum comprises:

- A metal pricing forum is convened and a presentation is made of the analysis based on forward prices and current budget prices for the immediate year and a range of long term prices (beyond five years).
- Real short term (< 24 months) prices from within the data and analysis are presented, debated and agreed upon.
- A real long term price from within the range presented in the analysis is debated and agreed on. Normally this trends towards the midpoint of range and slightly above the investment break-even price. The debate is guided so as to avoid overly optimistic or pessimistic views within the range.

- Having established the long term price and short term price points, (usually from the forward price and a six year long term price), the discussion moves to defining the trajectory between these two points. Minor adjustments are made to the metal price (in US$ terms) to ensure a smooth transition in ZAR terms to avoid anomalous ZAR revenue spikes (having conducted the core analysis in US$ and applied defined foreign exchange rates). This process is repeated for Pt, Pd, and Rh. Iridium and ruthenium prices are normally held flat at current prices owing to the uncertainty of this limited demand, specialist metals market.
- Gold and base metal prices are based on averages of expert opinion.

The metal prices (at associated exchange rates) are approved for a given scenario prior to inclusion in the global assumptions and adoption by the organisation.

11.5.7 Contribution to the Conceptual Framework

The global assumptions are a set of long term planning and economic parameters that best encapsulate the external drivers of value associated with a scenario or world view to be applied in business planning.

The aggregated parameters provide a descriptor of a current and future world view and transition between the two. When investment decisions are made in the context of these global assumptions, these decisions are positioned with the expectation that this future world view will evolve.

The global assumptions provide the link between the agreed world views or scenarios and the associated economic parameters for valuation purposes.

The global assumptions create discipline and uniformity of assumptions, as they are the only economic planning parameters permitted to be applied across the organisation for planning and valuation purposes. This facilitates comparison and ranking of options.

11.6 Value based management (VBM)

11.6.1 Introduction

"Central to the success of any mining company is the ability to effectively manage capital investment so as to ensure acceptable stakeholder returns within an overall strategic context. Typically a mining company investment portfolio would encompass options ranging from geological exploration through to market development. A key challenge is thus to ensure the alignment of investment with strategic intent whilst ensuring that the day to day viability of operations is not compromised. Critical to this process is the effective selection and implementation of a strategically aligned project portfolio that enables optimal resource exploitation whilst operating within mandated bounds and identified constraints" (Smith *et al*, 2006a, p.35).

"Owing to the depleting nature of the mineral resource asset it is necessary to continuously re-invest to sustain production, let alone expand. Capital investment is thus the life blood of minerals companies. Within this context there are often many competing investment imperatives that can divert funding from critical projects. Alignment of capital investment with strategic intent can be readily achieved through structured planning processes based on optimisation (value maximisation) of underlying exploitation units and subsequent structured competition for financial resources" (Smith *et al*, 2006a, p.41).

Value based optimisation of the mineral asset portfolio provides the basis on which the most attractive strategic options across the business are identified, prioritised, resourced and implemented. Similarly value based optimisation provides the basis for optimal allocation of capital for developing mineral assets and associated business opportunities through the value chain.

Exemplars in managing for maximum value exhibit key characteristics of:

- Detailed understanding of sources and drivers of value;
- Focused value improvement and delivery agendas; and
- Differentiated business models and differential allocation of resources.

The core sources of sustainable long term value accretion are indicated in Figure 11.6.1, specifically improving returns on existing assets and accelerating profitable growth.

The key questions that value based optimisation should answer, specifically in terms of the mineral asset portfolio, are:

- What is profitable growth, now and in a possible future world view?
- Which of the options (or combination of options) should be prioritised to allow sustainability and flexibility for value accretion?

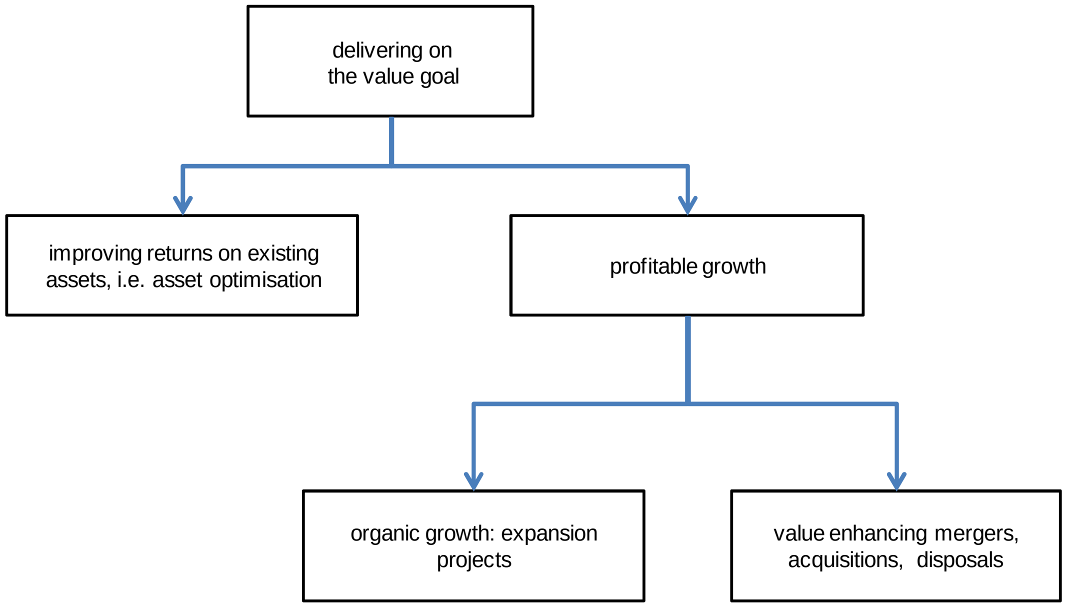


Figure 11.6.1 Value based optimisation – core sources of long term value

Within the inherent characteristics of demand/supply/price cycles in the minerals industry and the long lead times required to bring mining projects to steady state outputs and sustainable financial viability, it is important that flexibility be created to respond to changing market and economic conditions.

11.6.2 Value based management – core concepts

VBM defines the business model and sets out management and strategic agendas using three steps (Figure 11.6.2):

- Understanding of the sources and drivers of value in the markets;
- Evaluation of options for the largest value improvements; and
- Commitment to a clear implementation plan.

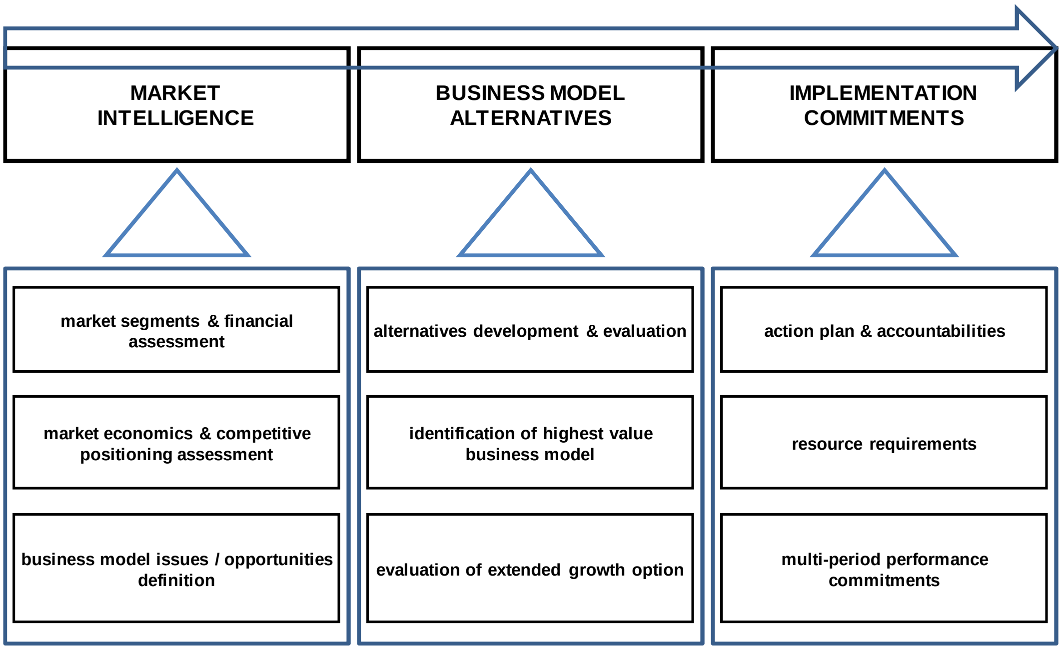


Figure 11.6.2 Three core steps to value based management

Market intelligence

The first step is the development of market intelligence that aims to build a deep understanding of the sources and drivers of value in the markets. The fact base must address two questions:

1) How attractive is the market today and in the future?

This market analysis covers the overall market value chain, products, key customers, end-users, commercial side structures and market segments by investigating key sources and drivers of profitability for each segment and player in the segment. Historical performance and reporting, as well as anticipated future trends (Smith *et al*, 2008) per market segment are reviewed and analysed, and understanding of key drivers is developed.

The market segment and associated financial assessment therefore addresses key questions around the profitability of specific outlets and customers in order to prioritise customers and segments and drive marketing strategy. Within the market for platinum specifically, contracts are usually long-term in nature and therefore using VBM to identify and target specific segments or customers could provide competitive advantage in a market where little or no differentiation in final product exists.

2) What are the sources and drivers of competition in the market?

The second question requires that an economic profitability analysis be conducted and understanding of mineral economics and market economics be used to identify drivers of competitive advantage. Sources of competitive advantage are:

- Pricing position;
- Offering position; and
- Cost position.

Economic profitability (EP) is used to evaluate the different players in the market and identify sources of advantage. Economic profit (EP) is a reflection of net operating profit after tax (NOPAT) of the business (or project, or operation) less a charge for the capital required to earn that return. NOPAT is an operating performance measurement after taking account of taxation but before financing cost (i.e. interest is excluded). NOPAT provides a more realistic measurement of the actual cash yield generated from recurring business activities.

EP = NOPAT - capital charge

= operating profit x (1 - effective tax rate)

- (average capital employed x weighted average cost of capital)

Economic profit will increase if:

- New capital is invested in any project that earns more than the cost of capital;
- Capital is diverted or liquidated from business activities which do not cover the cost of capital; or
- NOPAT increases without increasing the quantum of economic capital employed.

Economic profit explicitly recognises, by way of the capital charge:

- That capital is not free;
- That if growth is purchased with capital, the growth is not free; and
- Assigns a charge for the capital used to purchase the growth.

The summation of the present value of a stream of economic profit, where the discount rate is the cost of capital, equals NPV.

EP thus provides the means for value optimisation in the short term whereas potential overall investment value is predicted by NPV. This allows a link between short term value optimisation through real options whilst establishing long life production assets where the initial investment decision is based on a discounted cash flow approach.

Thus if the NOPAT is greater than the capital charge, the entity is generating returns above the cost of capital and so creating real sustainable value. However it does not indicate if performance is good or bad relative to competitors or if new investment should be allocated for growth. It also does not in any way suggest why value is created – this requires an understanding of the strategic drivers of value.

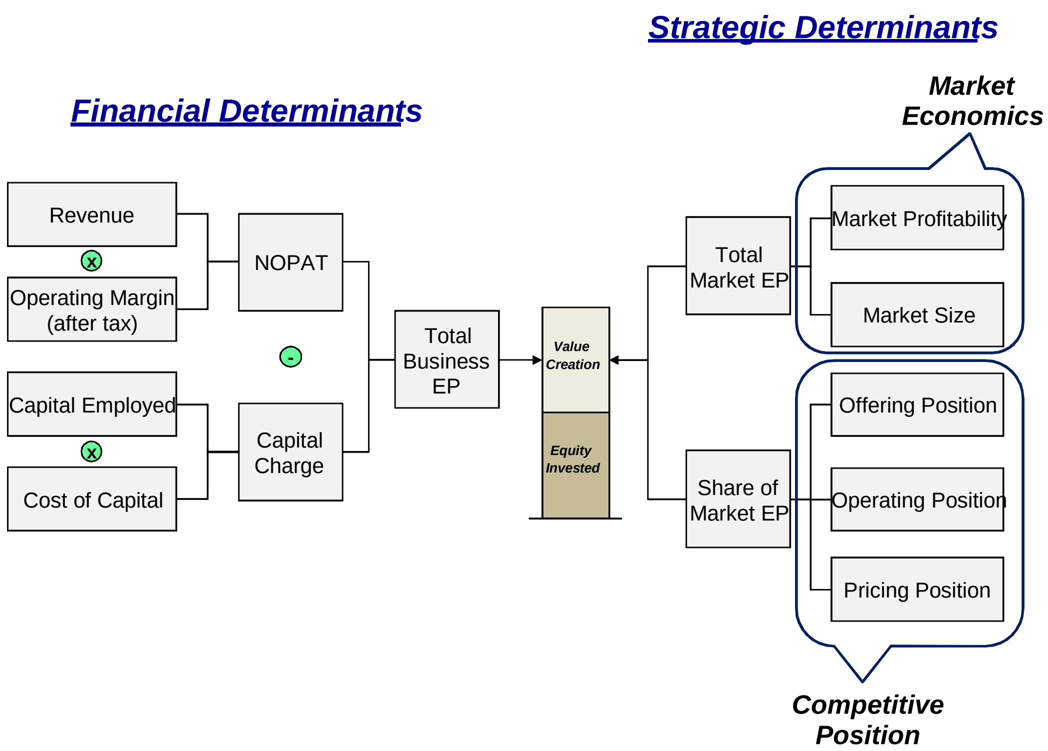


Figure 11.6.3 Strategic determinants of value – market and competitive position

Managing for maximum value is not simply a financial measurement exercise. As indicated in Figure 11.6.3, the strategic decisions and the financial results are directly related and are impacted by the decisions made about which markets to serve and how to serve them. It is important to note that there are only two strategic determinants of value:

- Market economics determine the total size of the profit pool; and
- Competitive position determines the share of the profit pool that is captured.

Mining businesses usually have a good understanding of the financial determinants of value, however understanding of the strategic determinants of value and how they may develop in the future is crucial to value maximisation and strategic long term planning.

Key elements of the analysis are indicated in Figure 11.6.4. Both pricing and offering have been consistent between industry players during the past few years of rapid growth. Cost position for all players is becoming more important, even though metal prices are presently outpacing costs. The economic profitability measure allows differences in earnings from differences in metal baskets, differences in capital expenditure and cost differentials to be crystallised and understood in depth.

Importantly having more volume in the market than other players is a comparative advantage, indicating access to mineral resources, and not a dynamic competitive advantage, that usually arises from knowledge application.

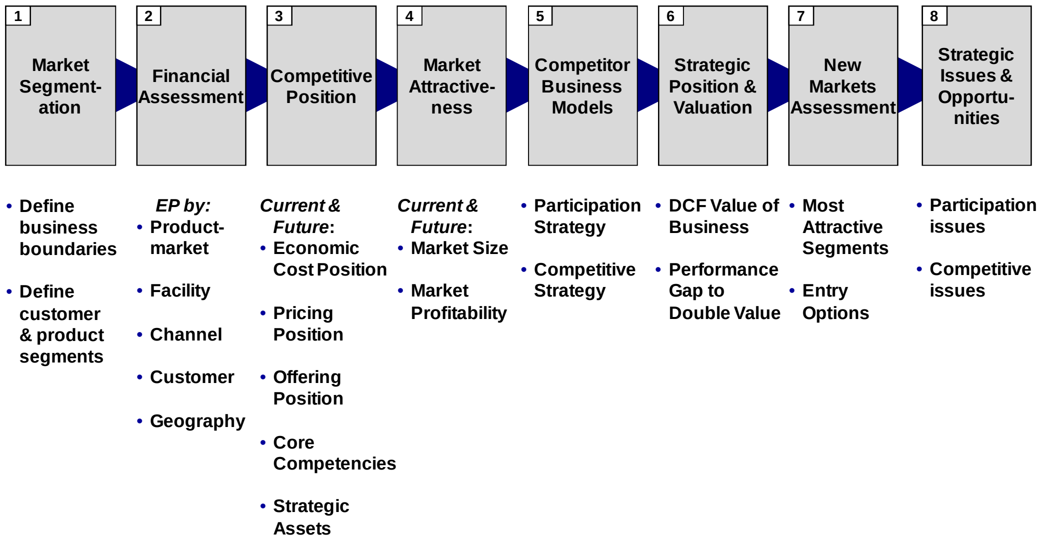


Figure 11.6.4 Key elements of market intelligence analysis

The final activity in the market intelligence collation utilises information on market segmentation and competitive positioning to identify potential opportunities and issues for the organisation. This is where full agreement on the facts that drive decision making, becomes useful. Establishing executive agreement on the market analysis and competitive positioning allows rapid consensus on strategic issues and opportunities. Having an agreed market intelligence view to drive strategic decision making has intrinsic value in that it aligns everyone's view by contextualising the industry and the role of the business within the greater system.

Business model alternatives

The second phase in the VBM process involves identification of business alternatives, both at the strategic level and the operational level, evaluation of the alternatives and decision making on the maximum value alternative for the organisation. Maximum value is defined as the model that will maximise business value on an economic profit basis. Finally, extended growth options are defined based on the preceding analysis.

This is a challenging part of the VBM process as it requires application of business acumen and wisdom to the accumulated market intelligence, to develop business alternatives. No simple formula can assist in identifying business alternatives. However, economic profitability measures are used to evaluate, rank and prioritise the business model alternatives that are developed.

Identification and evaluation of alternatives is important because:

- The process leads the executive towards making real choices and trade-offs for what they will and will not do;
- It encourages consideration of more radical changes as well as improvements to existing business strategy (both ‘in the box’ and ‘outside the box’ thinking);
- It helps to clarify where and why company profitability differs from company to company; and
- It challenges ‘conventional wisdom’ and ‘organisational inertia’ which could otherwise maintain the status quo or retain existing business models.

Combining metal demand forecasts, segment profitability and competitive positioning across a diverse range of mineral assets and potential projects creates many possible business alternatives. Using scenario planning or world view tools, the business alternatives can meaningfully be grouped and analysed for robustness under changing circumstances (Smith *et al*, 2008).

As indicated in Figure 11.6.5 a business’s strategic position and value creation potential is driven by the business model choices that it makes, viz. where does it compete, how does it compete and how is it organised to achieve these objectives?

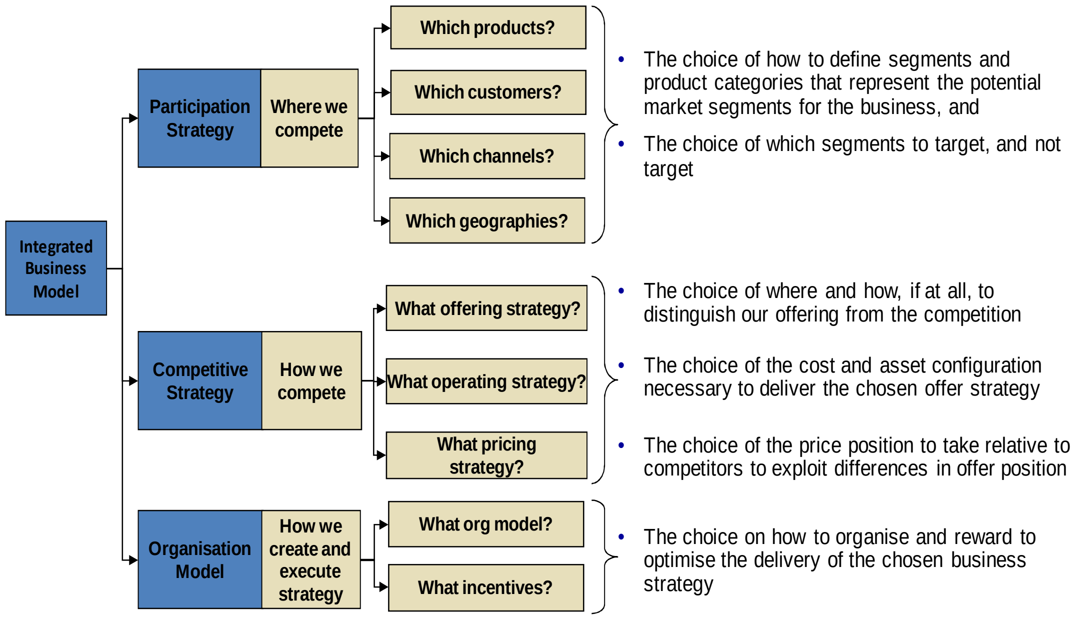


Figure 11.6.5 Business model – strategic positioning

Within this context, maximising value is a higher standard than creating value and requires the constant search for higher value options which links into the need for cyclical strategic long term planning procedures that incorporate real option analysis of the 'way forward'.

Implementation commitments

VBM provides the basis for decision making that can lead to enhanced value creation however this is dependent on effective commitment and implementation plans. Common wisdom holds that companies that make explicit commitments to value improvement targets are as likely to be more effective in implementation.

Implementing VBM requires the training of senior management in the system philosophy, principles and logic of critical metrics. Managers are expected to commit to the VBM philosophy at all levels of the organisation. Simply adopting economic profit, as embodied in the VBM framework as a value measure, will not result in value creation. Plans need to be executed and individuals held to account for success and failure.

11.6.3 Contribution to the Conceptual Framework

The logic inherent in value based management (VBM) is not new to business or the mining industry and has been practised in a variety of forms for several years.

Essentially value based management:

- Provides a set of metrics and a logic framework for value and prioritisation discussions;
- Ensures alignment of objectives, establishes a common language, standards, and processes to align decisions and actions;
- Provides a common approach to setting goals, identifying issues and opportunities, making decisions, allocating resources and taking action; and
- Creates a common set of tools and approaches to understand sources and drivers of value, prioritise issues and evaluate options.

What is different however is the adoption of the logic and its application to the strategic long term planning framework. The key question that VBM answers in this process is: What is profitable growth, now and in a possible future world view and which of the options should be prioritised?

11.7 Long term planning processes and techniques

This section describes the tools and processes that are applied in the development of a business plan within the strategic long term planning framework. Consideration is given to aspects of long term planning procedures specifically the planning cycle, mine extraction strategies, mining right plans, and the long term plan.

11.7.1 The business plan process

Cyclical development and re-evaluation of planning outputs is necessary to assess impacts of external factors, specifically the impact of changes to the long term planning parameters on the long term plan, at an operation and group or portfolio level.

Owing to the annual nature of financial reporting, an annual business planning (BP) cycle has been developed, with the following objectives:

- To enable integration between Corporate and Operations, both mines and process operations, and between MRM / Finance / Business Development / Projects;
- To improve the quality of product in long and short term planning by better balance of effort between the two;
- To create a planning process that is routine but sufficiently adaptable, and which allows for planning flexibility;

- To facilitate communication between stakeholders (Corporate, Operations, Services, Projects);
- To define the process, its components and inter-dependencies;
- To produce a defined product which is aligned to expectations; and
- To define clear accountability, roles and responsibilities.

The approach is structured around five broad principles.

Philosophy (the underlying rationale)

Key elements are:

- Business planning is done to produce a plan which optimally exploits the company's mineral resources. The plan must have integrity, mirror the company's intent, and be used at the highest level of strategic decision making; and
- Time spent by the executive on business planning should be minimised but the quality of input must be maximised.

Programme (when the work gets done)

Core principles are:

- The work programme should be simple, repetitive, integrated and take cognisance of other events in the company's calendar;
- Be primarily driven by five engagements with the executive (see Table 11.7.1); and
- Match budget requirements and timelines (internal and shareholders).

Process (what gets done)

Requirements are:

- The technical work to be done within each discipline must be mapped out with interdependencies defined and understood; and
- Performed in accordance with the standards laid down by the discipline heads (the technical scope of work documents).

Product (the output)

Included are:

- Deliverables clearly defined:
  - A budget (typically two to three year period);
  - The business plan itself;
  - A valuation of the company's mineral assets (inclusive of projects); and
  - The published mineral reserve and resource.
- Inputs clearly defined:

  - Preliminary life of mine (LoM) production profile;
  - The planning brief and top down goals; and
  - Technical scope of work documents.
- Output per operation:
  - Technical support documents;
  - Budget book – three year period by month;
  - Business plan book – budget period plus life of mine (annually); and
  - The physical LoM plan.
- Divisional business plan, budget summaries and presentation; and
- The company's business plan document and presentation.

People (who does what)

Requirements are:

- Requisite skills and competence must be entrenched; and
- Clear roles, responsibilities and accountabilities must be defined and accepted.

Overall the approach is intended to establish a systematic sequence around:

- Planning the work;
- Executing the work;
- Technically reviewing the work (single discipline reviews – SDR);
- Reviewing the product (multi discipline reviews – MDR); and
- Presenting the outcomes to the executive for approval before execution.

Through this approach the participants in the process should then know:

- Why this particular approach is used;
- How the work gets done and how all the parts fit together;
- When the work gets done (including reviews and presentations);
- Who does the work and who reviews the outcomes; and
- What the format of the work is; as a product and for presentation.

The overall structure of the annual business planning programme is predicated on five engagements, aligned in four quarters, with the executive to ensure alignment and effective engagement / information dissemination.

First quarter (Q1) – An executive directive is issued on strategic intent and constraints, following an annual strategic planning workshop in February. This is followed by feedback of the mine extraction strategy options at the end of March in the ‘Theme and Emphasis’ workshop.

Second quarter (Q2) – Presentation of ‘Tons and Ounces’ to executive at the end of June. This is a presentation of a production profile, with indicative capital requirements, that meets the strategic intent provided in February and agreed to in March.

Third quarter (Q3) – Budget preparation and approval for a three year window. Detailed production, operating and capital cost estimates.

Fourth quarter (Q4) – Finalisation and presentation of the business plan encompassing the budget and long term plan.

The overall approach is indicated in Table 11.7.1 with the link between the interdependent, tactical and strategic, planning elements created through consideration of planning requirements over different time horizons.

Table 11.7.1 Business planning calendar – summary

PERIOD	QTR 1	QTR 2	QTR 3	QTR 4
BUSINESS PLANNING PHASE	**PHASE 1** **BUSINESS PLAN PREPARATION** **SCENARIO PLANNING**	**PHASE 2** **3 YR PRODUCTION PLAN**	**PHASE 3** **3 YR BUDGET &** **LOM PRODUCTION PLAN**	**PHASE 4** **BUSINESS PLAN FINANCIALS** **RESOURCES & RESERVES**
MAIN ACTIVITIES & PRODUCTS	**Resource & Reserve – Model Distribution** **EXECUTIVE STRATEGY SESSION** Scenarios and Options Project Ranking and BP Status Business Plan Architecture Executive Guidance Business Development Input & GA's **PRELIM LOM PROFILES (t & oz)** Technical Scope of Work Documents **Plan Inputs -** Geology – structure, facies, grade model Mine Design – macro, micro Rock Engineering – design elements Ventilation – design elements Process – capacities & constraints	**Top Down Goals – Tonnes & Ounces** Planning Brief 36 month Production Schedule and Plan Equipping Schedule IMA (immediately available Reserves) IMS (immediately stopeable Reserves)	**3 Year Budget – Financials** Labour Opex Capex - Projects Capex - SIB **Project Financials & Valuations** LOM Scheduling - L1, L2, L3 **LOM PLAN** **Reserve Compilation** **PROJECT Steering Committee Reviews** Pre-Feas & Feasibility Studies	**LOM – Financials** Opex Capex Projects **BP Executive Summary** Finalise **MINE Bus. Plan Documents** Finalise **COMPANY Bus. Plan Document** Resources & Reserves into **Database** Finalise next year Planning Programme Investor & Competitor Analysis
DISCIPLINE REVIEWS	**SDR = discipline head** (before the planning starts) Geology, Planning, Mine Design, Rock Engineering, Ventilation, infrastructure, Capacities & Constraints	**SDR's** (of the 3 year plan) 3 Year Scheduling Equipping	**SDR's** (of the 3 year plan financials) Finance, H/R, Labour, Opex, Capex LOM Scheduling	**SDR's** (of the long term plan) Labour, Opex, Capex Executive Summary Resources & Reserves
	MDR = mining management committee Scenarios, Options, Business Planning Architecture, Planning Brief, Preliminary LOM Profiles	**MDR's** 3 Year Plan BMEs & Graphs Check & Re-issue LOM Brief	**MDR's** **Budgets**: BFEs and Graphs **LOM Incl Projects** : Profiles, BMEs, Graphs **Project** : Budget Capex	**MDR's** Business Plan Project Valuation Executive Summary Resources & Reserves
EXECUTIVE REVIEWS & PRESENTATIONS	**Exeecutive debrief to MRM - (post strategy)** **Executive Heads Review** Options, Preliminary LOM Profiles, & Brief	**Exec Heads Review** 3 Year Production Plan Check & Re-issue LOM Brief	**Exec Heads Review** 3 Year Budgets Incl Projects	**Exec Heads Review** Business Plan & Reserves
	THEME & EMPHASIS DAY **TDG's and sign off on 'Desired Plan'**	**TONNES & OUNCES DAY** **3 Year Production Plans** **and Check LOM Profile**	**BUDGET DAY**	**BUSINESS PLAN DAY**

Within this context it is necessary that each operation develops and articulates a mine extraction strategy (MES), from which a mining right plan (MRP) can be developed and the budget and long term plan (LTP) extracted, to form the overall business plan (BP). Each step in the process is a path along a decision tree with choices being identified, rationalised, motivated and implemented.

The long term plan then informs all other disciplines within the business as to supporting requirements to create the business plan. For example the LTP will inform the concentrator and processing strategies to ensure alignment with overall group strategic objectives. Similarly in the human resource area it would provide the basis for staffing, skills development and housing requirements.

The overall relationship between these elements is indicated in Figure 11.7.1

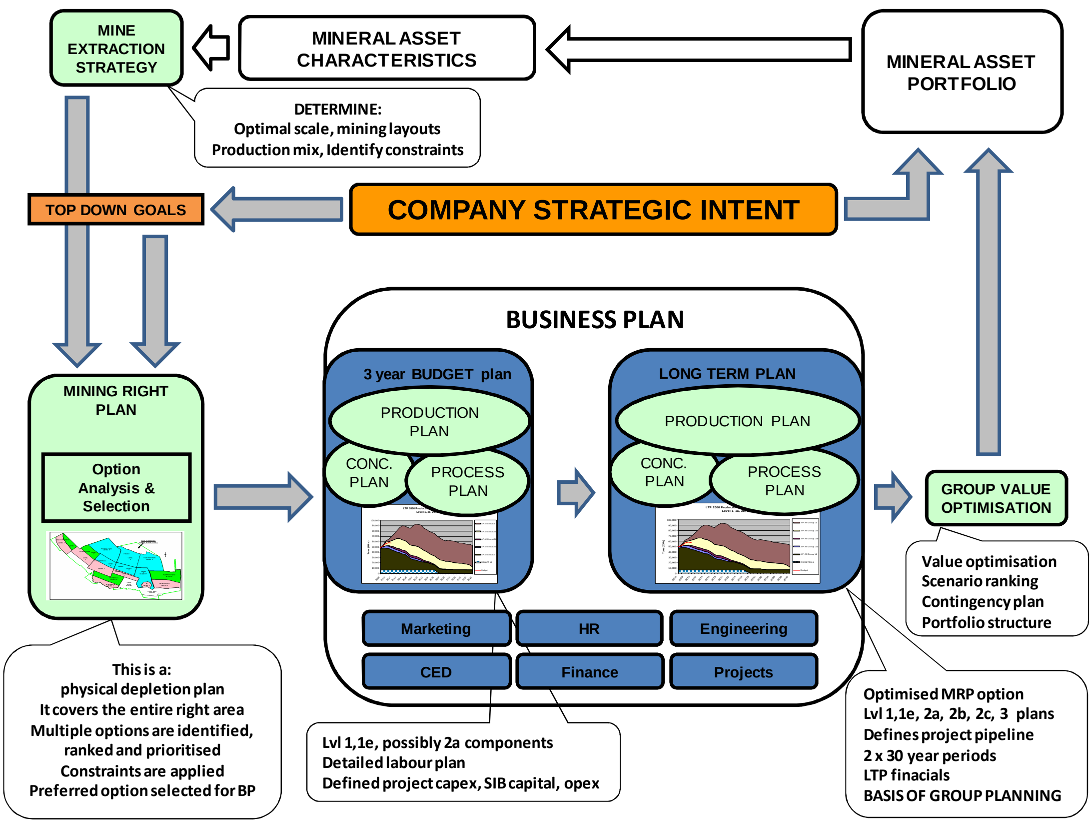


Figure 11.7.1 MES to MRP to LTP linkages in the business plan

The mine extraction strategy (MES) is informed by the characteristics of the mineral asset itself, whilst company strategic intent informs the top down goals. Both the MES and the top down goals, inform development of the mining right plan (MRP). The MRP in turn impacts the composition of the budget and long term plan, which comprise the business plan (at an operation level and in a group consolidated form) which in turn influences optimisation of the mineral asset portfolio.

The business plan covers the life of the operation or the first 60 years (two periods of 30 years to align with the MPRDA) whichever comes first. It comprises a combination of investment centres at different levels of confidence of estimate, viz. level 1, 1e, 2a, 2b, 2c and 3 (see Section 11.7.4). The business plan forms the basis of the production and cost (opex and capex) forecasting for the group and is used for capital prioritisation and value optimisation.

11.7.2 Mine extraction strategy

The mineral resource held under a mining right is the fundamental asset from which value is derived by a mining company. In order to optimise economic return (viz. to maximise net present value), clarity is required on:

- How the entire mineral resource associated with the mining right area is to be exploited (this is a legal requirement);
- Over what time period; and
- At what cost (capital and operating).

The mine extraction strategy sets the context in which all other strategic long term planning is done. Key issues that must be addressed are:

- Optimal scale of operations;
- The associated tonnage source split, e.g. Merensky / UG2;
- Technology selection and associated mining layouts;
- Identification of critical constraints, e.g. water supply, tailings disposal;
- The influence of existing asset base, e.g. timing to optimal rate and split; and
- Identification of consequences for process capacity / or other critical interfaces, e.g. human resources and infrastructure.

It is important to note that the mine extraction strategy is not the plan but a clear, motivated statement of the basic rules that will guide development of the mining right plan and the subsequent long term plan upon which investment decisions will be made.

The mine extraction strategy thus informs the nature of the mining right plan specifically: optimal scale, associated MER / UG2 ratio, basic infrastructure options and critical constraints. The MES is an unconstrained view of the ultimate potential of the mineral asset.

Studies conducted in developing the mine extraction strategy will be a combination of existing operations plans at level 1 (i.e. the base scenario from which the operation would evolve), existing project evaluations at study levels of 2a (feasibility), 2b (pre-feasibility) and 2c (conceptual), with the remainder of the mining right area being considered at level 3 (scoping study).

Mine scale optimisation profile

Critically, the optimal rate of extraction of a mining right area must be defined, as a key strategic planning input, before these issues can be rationalised. Essentially this is a physical, geometric issue defined by the mineral resource characteristics and the technology selected for extraction. This is, however, not a trivial process owing to interdependencies, the effect of existing infrastructure and the need to concurrently sustain output according to an approved budget in a safe, cost effective and competitive manner.

This optimal rate of extraction is identified from a mine scale optimisation profile (NPV versus production level) developed by considering, from the existing infrastructure base, the following:

- An unconstrained Merensky profile – viz. if a decision was taken to mine only Merensky what would be the mine production, capex, opex profile;
- An unconstrained UG2 profile – viz. if a decision was taken to mine only UG2 chromitite what would be the mine production, capex, opex profile; and
- A mixed MER / UG2 unconstrained profile, where MER and UG2 are mixed to get volume synergies or to phase in marginal projects on the basis of stronger initial projects or infrastructure establishment.

Note: In this context, unconstrained means that no capital constraint is applied.

It is important that extraction be considered in logical building blocks based on standardised outputs, efficiencies and costs (capex, opex) as defined by mining engineering requirements. Any logical dependencies, e.g. sequencing of extraction, must be honoured and the plans must be feasible. Ranking of the logical building blocks should be based on mining unit value (contribution before consideration of concentrating and indirect costs) to ascertain the core value potential of a logical building block before addition of concentrator capex.

The three profiles (Merensky, UG2 and mixed) are assessed at three revenue scenarios based on world views, typically: approved, optimistic and conservative long term macroeconomic and planning parameters (known generally as global assumptions) to identify the range of the scale of operations. This approach, which provides scale, mix and value combinations is represented schematically in Figure 11.7.2.

This optimal production range is core to the mine extraction strategy and should drive the resultant mining production profile depicted in the long term plan and the consequent concentrator and downstream processing strategy.

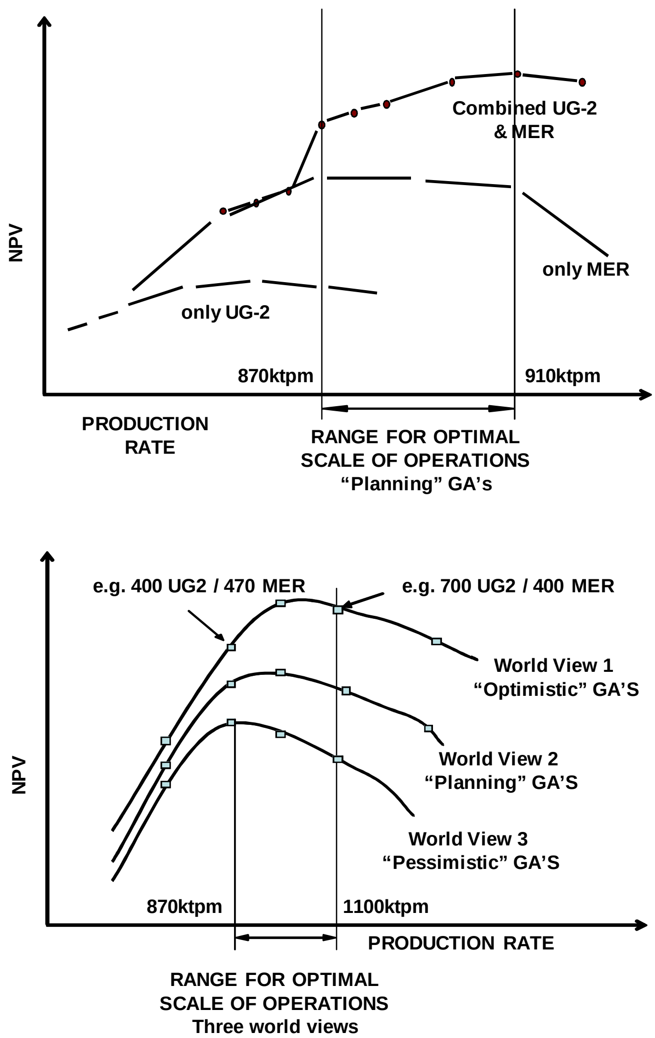


Figure 11.7.2 Mine scale optimisation profile – schematic

<u>Production mix: UG2 to Merensky ratio</u>

In order to maximise value generation from the mineral resource over the initial 30 year and subsequent 30 year renewal periods granted in terms of the MPRDA, co-extraction of multiple reef horizons may be necessary (e.g. Merensky and UG2). Co-extraction must be driven by two factors:

- Extraction of the higher value (NPV) horizon first; and
- Concurrent completion of extraction of both horizons on or before the expiry of the two 30 year periods if possible.

These factors imply an approach based on:

- Maximising the higher value horizon, for any given infrastructure, whilst co-extracting (on an incremental basis) the second horizon so as to ensure volume / scale benefits; and
- Adjusting extraction rates to achieve concurrent termination dates to avoid sterilisation of mineral resources at the end of the life of the operation.

The starting point for this process is the existing infrastructure base, which because of the history of initial Merensky mining, may dictate a short term bias towards UG2 projects, until such time as the optimal mine scale profile and value mix is achieved. The MRP / LTP should indicate the planned trajectory, in terms of the mine extraction strategy, to achieve the optimal scale of operations and production mix characteristic of the mining right area.

<u>The influence of metals prices and foreign exchange rates on the strategy</u>

The tenor of macroeconomic and planning parameters or global assumptions applied to the valuation of options will impact decisions on overall viability, and critically, selection of the primary extraction horizon.

The global assumptions applied in the LTP process are smoothed and stabilised in an attempt to avoid overly pessimistic or optimistic long term views. This approach should ensure that valid long term investment decisions are not delayed or curtailed because of short term market aberrations.

Additional metal pricing scenarios are developed that cover an upside (optimistic) and downside (conservative) perspective linked to world views or scenarios and are readily applied in the customised software used for financial modelling (Hyperion Strategic Finance - HSF).

It is still however critical to understand the sensitivity of any production mix strategy to changes in metal prices / foreign exchange rates. This is determined by conducting a transition analysis for a range of platinum and palladium prices.

Figure 11.7.3 represents a typical transition surface analysis in which the price combinations of Pt and Pd can be identified at which Merensky extraction is superior to UG2 (black positive numbers) and UG2 extraction is superior to Merensky (red negative numbers). Marginal areas (green and brown cells) and non-viable price combinations i.e. both Merensky and UG2 negative (red cells) are also identified.

Cash flow before tax based on total cost ($/m2): Merensky advantage over UG2

Pt $/oz	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
1500	70	68	67	66	64	63	61	60	59	57	56	54	53	52	50	49	47	46	45
1450	67	66	64	63	61	60	59	57	56	54	53	52	50	49	47	46	45	43	42
1400	64	63	62	60	59	57	56	55	53	52	50	49	48	46	45	43	42	41	39
1350	62	60	59	57	56	55	53	52	50	49	48	46	45	43	42	41	39	38	36
1300	59	57	56	55	53	52	50	49	48	46	45	43	42	41	39	38	36	35	34
1250	56	55	53	52	51	49	48	46	45	43	42	41	39	38	36	35	34	32	31
1200	53	52	51	49	48	46	45	44	42	41	39	38	37	35	34	32	31	30	28
1150	51	49	48	46	45	44	42	41	39	38	37	35	34	32	31	30	28	27	25
1100	48	46	45	44	42	41	39	38	37	35	34	32	31	30	28	27	25	24	23
1050	45	44	42	41	40	38	37	35	34	33	31	30	28	27	26	24	23	21	20
1000	42	41	40	38	37	35	34	33	31	30	28	27	26	24	23	21	20	19	17
950	40	38	37	35	34	33	31	30	28	27	26	24	23	21	20	19	17	16	14
900	37	36	34	33	31	30	28	27	26	24	23	21	20	19	17	16	14	13	12
850	34	33	31	30	29	27	26	24	23	22	20	19	17	16	15	13	12	10	9
800	31	30	29	27	26	24	23	22	20	19	17	16	15	13	12	10	9	8	6
750	29	27	26	24	23	22	20	19	17	16	15	13	12	10	9	8	6	5	3
700	26	25	23	22	20	19	18	16	15	13	12	11	9	8	6	5	3	2	1
650	23	22	20	19	18	16	15	13	12	11	9	8	6	5	4	2	1	(1)	(2)
600	20	19	18	16	15	13	12	11	9	8	6	5	4	2	1	(1)	(2)	(3)	(5)
550	UG2 -ve	16	15	13	12	11	9	8	6	5	4	2	1	(1)	(2)	(3)	(5)	(6)	(8)
500	Both -ve	UG2 -ve	UG2 -ve	11	9	8	7	5	4	2	1	(0)	(2)	(3)	(5)	(6)	(7)	(9)	(10)
450	Both -ve	Both -ve	Both -ve	UG2 -ve	7	5	4	2	1	(0)	(2)	(3)	(5)	(6)	(7)	(9)	(10)	(12)	(13)
400	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	1	(0)	(2)	(3)	(5)	(6)	(7)	(9)	(10)	(12)	(13)	(14)	(16)
350	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	(5)	(6)	(7)	(9)	(10)	(12)	(13)	(14)	(16)	(17)	(19)
300	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	M -ve	M -ve	(11)	(13)	(14)	(16)	(17)	(18)	(20)	(21)
250	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	M -ve	M -ve	(17)	(18)	(20)	(21)	(23)	(24)
200	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	M -ve	M -ve	(23)	(24)	(25)	(27)
150	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	M -ve	M -ve	M -ve	M -ve	(30)
100	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	Both -ve	M -ve	M -ve	M -ve

Pd $/oz

MER / UG-2 transition

Figure 11.7.3 Merensky / UG2 transition surface analysis

The transition surface analysis estimates the cash flow before tax, associated with revenue and cost structures attributable to a particular area (such as a mine or a shaft) for the Merensky and UG2 horizons. Plotting of the long term Pt and Pd price forecasts on the diagram then allows assessment of the potential risk associated with the selected extraction mix strategy. If a long term price forecast plots close to or on the transition surface between Merensky and UG2, it indicates the need to plan infrastructure and production capacity that can readily shift from one horizon to the other (as the primary extraction horizon) in the event of a sustained move in metal pricing.

Essentially, if a shaft is designed and defined as a Merensky shaft with no access to or flexibility for UG2 production and the long term price forecasts plot on or near the MER/UG2 transition surface, then the design is fundamentally flawed.

11.7.3 Mining right plan (MRP)

This is a physical depletion plan that covers the area over which mining rights have been granted in terms of the MPRDA. As such it is not time limited and has a life, which is a result of the optimal scale of operations as identified in the mine extraction strategy.

The MRP is driven by the mine extraction strategy (scale of operations, layouts, existing asset base, Merensky / UG2 split, constraints). It is not necessary that the MRP be economically viable but rather that the full extent of the mining right area be planned in a technically defensible manner at estimates that are current for capex, opex and the global assumptions. Several options (normally extraction sequencing) should be developed in order to identify an optimised plan (maximised NPV) plan.

The planning horizon of the MRP must cover the entire mining right area – viz. it is not time constrained but area constrained. A comprehensively scheduled mining right plan (MRP) will result in a view of the mineral resource potential and the mining and concentrating capacity and cash flow required to achieve it.

The MRP forms the basis of annual reporting and updating of the mine works programme as required by the Minerals and Petroleum Resources Development Act. The MRP is reviewed and updated annually as part of the long term planning process.

Key elements to the basic methodology are:

- Freeze and review geology, structure and mineral resource models;
- Define a mining engineering design template (e.g. stope back length, replacement rates);
- Apply mining templates to the mineral resource to logically segment the properties into mining units;
- Determine mineral reserves and depletion schedules using Datamine, CADSmine and APMOT;
- Determine mining capital cost and operating costs;
- Determine mining unit values (NPV of each mining unit exclusive of off-mine costs);

- Develop a depletion logic based on mining unit value ranking, e.g. highest value units first to carry initial capex cost of infrastructure and concentrators followed by lower value areas on an incremental basis;
- Determine the subsequent concentrator and infrastructure logic (including capex and opex);
- Identify critical constraints (e.g. water supply, electric power distribution, road access, etc.); and
- Conduct HSF valuations.

It is important to note that the logic applied in the MRP methodology is consistent with what is required to determine optimal scale of operations and the associated extraction mix. This is an iterative process. Similarly estimates will be a mix of confidence levels (1, 1e, 2a, 2b, 2c, 3) depending of the nature of the operation and/or project area.

Mining unit design logic

A consistent logical approach is required for the definition and use of mining units in the development of the MRP and MES:

- Mining units need to compare on a like for like basis – viz. the design assumptions should be consistent for blocks of ground with similar physical characteristics;
- Standardisation of mining units is essential – viz. use of a mining engineering design template;
- Realism is critical;
- Production build-up rates must be realistic and achievable;
- Head grades must be realisable;
- Mining efficiencies and concentrator recoveries should be attainable;
- Conservative operating costs (benchmarked) are important;
- Labour complements should be standardised for the applicable mine design;
- Realistic capital estimates must be made; and
- Design for value by:
    - Application of tried and tested fit for purpose access and mining methods;
    - Delaying capital expenditure until absolutely necessary;
    - Establishing potential value for each mining unit independently;
    - Establishing the likely synergies for combinations of units; and
    - Establishing the logical depletion order of units to minimise infrastructural requirements.

11.7.4 Long term plan (LTP)

The LTP is a plan (and associated economic analysis) indicating the optimised extraction option selected from the MRP. Cash flow estimates from the LTP are used to forecast estimates of value for a project, a mine and the group. The LTP is constructed from HSF investment centre (IC) models representing logical mining units (by reef type) and project area.

Planning – investment centre confidence levels

The structure and logic of the investment centre building blocks in both the mining right plan and the long term plan (leading to the business plan) are schematically illustrated in Figure 11.7.4.

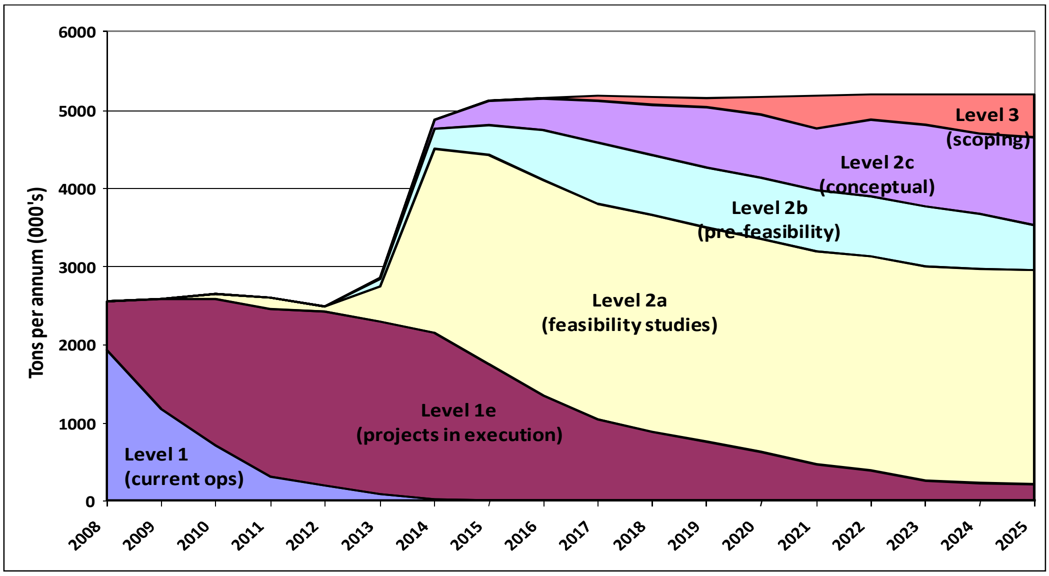


Figure 11.7.4 Schematic mining right plan showing investment centre estimate confidence levels.

The MRP and LTP leading to the business plan comprise of a number of investment centre models representing planning at varying levels of estimate confidence. Logically as study work is completed, investment centres progress from the lowest levels of confidence estimate through to execution.

Level 1 plans are effectively current operations (level 1) and approved projects in implementation/execution phase (level 1e) that have necessary project capital expenditure authorised and thus only require stay in business capital expenditure for the balance of planned life. The categories of stay in business capital expenditure are indicated in Figure 11.7.5.

Level 2 plans are effectively proposed capital investments or projects and are divided into three sub-categories (a, b & c), which are related to the confidence stage at which the respective proposed capital investment or project was last reviewed. These sub-categories are governed by a stage-gate review and approval process and comprise:

- Level 2a (Feasibility study@ +/- 10% estimate confidence);
- Level 2b (Pre-feasibility study @ +/- 15% estimate confidence); and
- Level 2c (Conceptual study @ +/- 25% estimate confidence).

Capital expenditure would be directly attributable to the proposed capital investment category (see Figure 11.7.5) and would be classified either as being an expansion or replacement project.

Level 3 plans effectively cover the remaining extent of potentially exploitable resource within the area covered by the current mining authorisation. The level 3 plans are at best, scoping studies and generally not subjected to a rigorous stage-gate review process);

Capital expenditure by definition would follow the classification methodology as applied to the level 2 models, with a very low confidence being attached to the capital estimates not better than +/- 30%).

Two sub- categories exist in level 3; 3a and 3b:

- Level 3a (Scoping study @ +/- 30% estimate confidence); and
- Level 3b (Scoping study @ > 30% estimate confidence based on pre resource material, ‘blue sky’ opportunities).

Despite the best efforts to plan and find viable means of extraction, an investment centre (project) may not form part of the business plan for two reasons: economics or insufficiency of engineering work. This gives rise to two other categories:

- Not in business plan - NIB (eng) – these are uneconomic investment centres which may have been subject to extensive study work through to pre-feasibility level but are uneconomic for current long term planning parameters; and
- Not in business plan - NIB (nw) – these are investment centres which have not had any study work done on them to date or where exploitation is planned well in the future (>30years).

The nature and relationship of these investment centre, confidence estimate, categories are further expanded in Table 11.7.2.

Table 11.7.2 Long term plan – planning level estimate confidence

Level	Sub Level	Plan description	Project Engineering	Resource	Scheduling	In Reserve
1	1	Optimised base plan excluding Board approved projects in execution	N/A	Measured and Indicated	CADS Mine	Yes
	1e	Fully optimised plan including current Board approved projects.	N/A	Mostly Measured and Indicated, some Inferred	CADS Mine	Yes
2	2a	As above including projects that have a completed pre-feasibility study and currently have a feasibility study in progress	Completed pre-feasibility study Feasibility study in progress	Measured to Inferred. Inferred not greater than 30%	CADS Mine	Yes
	2b	As above including projects that have a completed conceptual study and currently have a pre-feasibility study in progress	Completed conceptual study Pre-feasibility study in progress	Measured to Inferred. Inferred not greater than 50%	CADS Mine	by exception
	2c	As above including projects that have a completed scoping study and currently have a conceptual study in progress	Completed scoping study Conceptual study in progress	Measured to Inferred. Inferred not greater than 50%	APMOT	No
3	3a	Project at a scoping level	Scoping study	Measured to Inferred Inferred up to 100%	APMOT	No
	3b	Project at a scoping level	Scoping study	Pre resource Blue sky tangible (BST)	APMOT	No
NIB	NIB (eng)	Project has been engineered, but does not make it on economic grounds	Scoping, conceptual, pre-feasibility, feasibility	Measured to Inferred	Dependent on history of study	No
	NIB (NW)	No work has been done	None	Measured to BST	None	No

11.7.5 Capital expenditure categories

Capital expenditure is broadly divided into two categories:

- Project capital (expansion or replacement); and
- Stay in business capital (with sub-categories).

The purposes of this classification is to provide a more meaningful distinction between capital expenditure which is once off, and serves to expand or maintain total business capacity through the exploitation of new sites or near-mine sites, that is project capital, and capital which is expended in the maintenance of existing productive capacity (stay in business capital).

Figure 11.7.5 below outlines the capital categories that are used for valuation modelling of current operations and capital investment decisions.

Projects		Stay in Business Capital Categories						
Expansion (Proj E)	Replacement (Proj R)	Replacement of Equipment (RE)	Business Improvement (BI)	Risk			Ore Reserve Development (ORE)	Shared Infrastructure (SI)
Production Increases Capacity	Maintain Production Capacity			Safety (RS)	Legislation (RL)	Business (RB)		
Expansion Capital	**Ongoing Capital**							

Figure 11.7.5 Capital categories – project and stay in business

Project capital - expansion (Project E)

Expansion capital is applied to increase the overall production capacity of a particular operating unit. It also includes any concentrating, processing and refining facilities required to treat the additional capacity.

Project capital - replacement (Project R)

Replacement capital is applied to maintain the overall production capacity of a particular operating unit. A new project within a mining right area may be implemented to replace existing production capacity elsewhere within the operating unit.

<u>Stay in business (SIB) capital</u>

SIB capital is applicable for all capital equipment replacement, business improvement, risk mitigation, ore reserve development and shared infrastructure initiatives after the initial project execution. Generally this will include all capital installations beyond the initial capital footprint. Stay in business capital comprises seven main types:

- SIB replacement (SIB RE) capital
  This category is applicable to capital equipment replacement. SIB RE is based on project throughput and / or equipment utilisation and covers the systematic replacement of capital assets utilised in the production process.

- SIB business improvement (SIB BI) capital
  SIB BI is the capital associated with an initiative which will enhance the business (i.e. improve the return on investment) during the life of mine / plant. A SIB BI project is motivated during the course of a reserve being mined or during the life of a plant as the potential business improvement opportunity is identified.

- SIB risk (SIB RS, RL, RB) capital
  SIB risk covers projects necessary to mitigate or address risks associated with:
  - Safety (SIB RS);
  - Legislative (SIB RL); and
  - Business risk (SIB RB).

  The above risks arise during the mining of a reserve or operation of a plant.

- SIB ore reserve development (SIB ORE) capital
  SIB ore reserve development typically applies to situations where ground conditions necessitate opening up of a further ore reserve buffer to balance those lost (in order to maintain steady state production) which would include the costs incurred through transition zones, i.e. through major pothole areas, etc. This category should not be confused with situations where business takes a decision to:
  - Increase the capital footprint;
  - Change the method of mining thereby necessitating capital for equipping e.g. from trackless to conventional; or
  - Include either Merensky or UG2 where the original footprint did not allow for this.

  Any of the above should be captured as a change of scope to the initial expansion / replacement project.

- SIB shared infrastructure (SIB SI) capital
  This category includes all SIB projects which are not directly attributable to a particular project / production unit. Projects in this category typically service several projects / production units in an investment centre, shaft, mine or plant. SIB SI may be considered as a portfolio of projects, the capital costs of which are borne by the production units served by those projects. As such the SIB capital for these projects is allocated on a tonnage basis attributable to the respective investment centre, shaft, mine or plant. To improve resolution, projects in this category should ideally be tied to the particular investment centre, failing that to the shaft, and failing that to the mine or plant.

Stay in business capital categories (RE, BI, RS, RL, RB, ORE, SI) and project replacement capital (Project R) can be categorised as ongoing capital for reporting purposes if necessary. Project expansion (Project E) can be is categorised as expansion capital for reporting purposes if necessary.

11.7.6 Mineral resource and reserve linkages

The long term planning process does, by virtue of the structured linkage between planning, economic viability and business strategic alignment, facilitate definition of mineral resources and reserves.

The relationship between mineral resources and reserves, as defined in the South African code for the reporting of exploration results, mineral resources and mineral reserves (SAMREC, 2009) is indicated in Figure 11.7.6.

“A mineral resource is defined as being a concentration or occurrence of material of economic interest in or on the earth’s crust in such form, quality and quantity that there are reasonable and realistic prospects for eventual economic extraction. The location, quantity, grade, continuity and other geological characteristics of a mineral resource are known, or estimated from specific geological evidence, sampling and knowledge interpreted from an appropriately constrained and portrayed geological model. Mineral resources are subdivided, and must be so reported, in order of increasing confidence in respect of geoscientific evidence, into inferred, indicated or measured categories” (SAMREC, 2009, p.12).

Whilst “mineral reserve is considered as the economically mineable material derived from a measured or indicated mineral resource or both. It includes diluting and contaminating materials and allows for losses that are expected to occur when the material is mined.

Appropriate assessments to a minimum of a pre-feasibility study for a project and a life of mine plan for an operation must have been completed, including consideration of, and modification by, realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors (the modifying factors). Such modifying factors must be disclosed" (SAMREC, 2009, p.17).

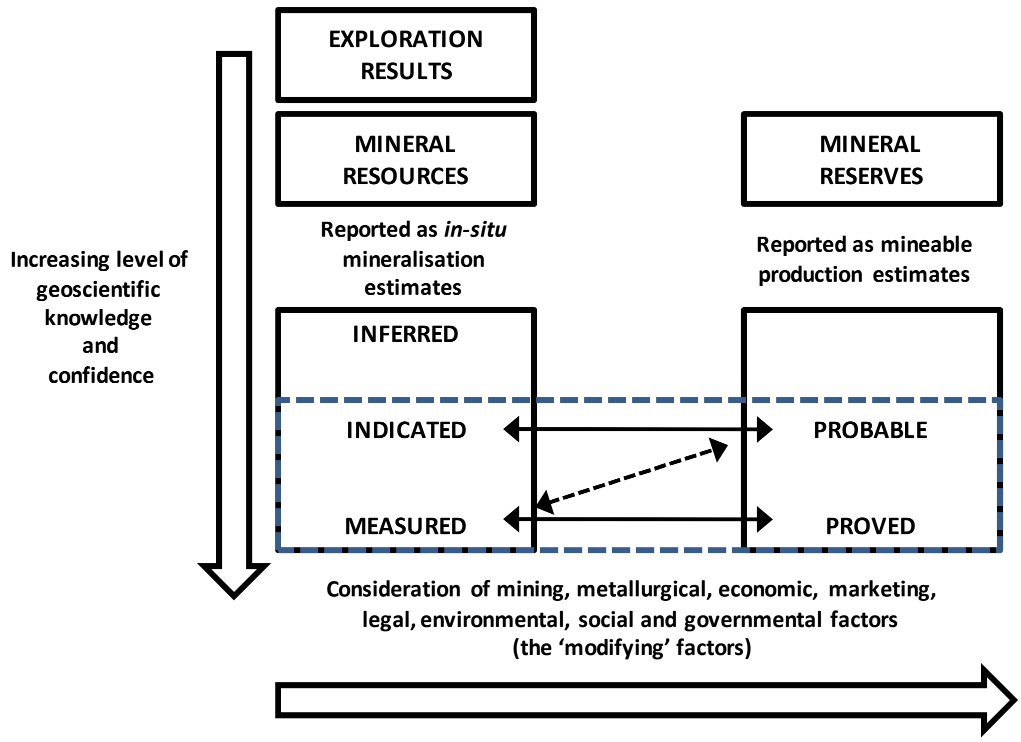


Figure 11.7.6 Relationship between exploration results, mineral resources and mineral reserves (after SAMREC, 2009).

Figure 11.7.6 sets out the SAMREC framework for classifying tonnage and grade estimates so as to reflect different levels of geoscientific confidence and different degrees of technical and economic evaluation.

Mineral resources can be estimated on the basis of geoscientific information with some input from other relevant disciplines and are reported as *in situ* mineralisation estimates.

To establish mineral reserves, which are modified indicated and measured mineral resources (shown within the dashed outline in Figure 11.7.6), requires consideration of the modifying factors affecting extraction. Measured mineral resources may convert to either proved mineral reserves or probable mineral reserves if there are uncertainties associated with the modifying factors taken into account in the conversion from mineral resources to mineral reserves. The broken arrow in Figure 11.7.6 demonstrates this relationship. Although the trend of the broken arrow includes a vertical component, it does not, in this instance, imply a reduction in the level of geoscientific knowledge or confidence.

The term modifying factors is defined to include mining, metallurgical, economic, marketing, legal, environmental, social and governmental considerations that would impinge on the decision to exploit the mineral resource.

The mining right plan, following definition of design and planning criteria during the mining extraction strategy definition, identifies what is technically feasible for a mining right area. This is a necessary requirement to maintain tenure of mineral rights.

The business plan, comprising a budget and long term plan, defines what is economically feasible within business and market constraints. Thus inclusion into the business plan automatically encompasses all elements of the modifying factors necessary for definition of the mineral reserve.

Mineral resources contained in the level 1 (existing operations not requiring project capital) and level 1e (approved capital projects in execution) scheduled areas, which form the base plan of the operation, should move automatically to mineral reserves (if they are at measured or indicated level of estimate confidence).

However, despite the SAMREC guidance that projects which are at a minimum of a pre-feasibility study level and are included in the life of mine plan, can be included in mineral reserves, a view must be taken on the likelihood of capital funding to extraction. Not all pre-feasibility studies advance to feasibility study, however most feasibility studies will advance to execution as they are aligned with company strategic intent and generally would only have been allowed to progress to feasibility study level if there was intent to fund the execution.

On this basis measured and indicated mineral resources which are scheduled for extraction and are included in the business plan at level 2a (projects in feasibility study) should be included in the mineral reserves of the operation.

The business plan thus readily defines mineral resources that would form part of the mineral reserves through consideration of mineral resources at levels 1, 1e and 2a which are scheduled for extraction. Mineral resources not converted to mineral reserves would then form part of the exclusive resource.

These concepts are represented schematically in Figure 11.7.7 whilst the relationship of mineral resources to mineral reserves in the project study pipeline is represented in Figure 11.7.8

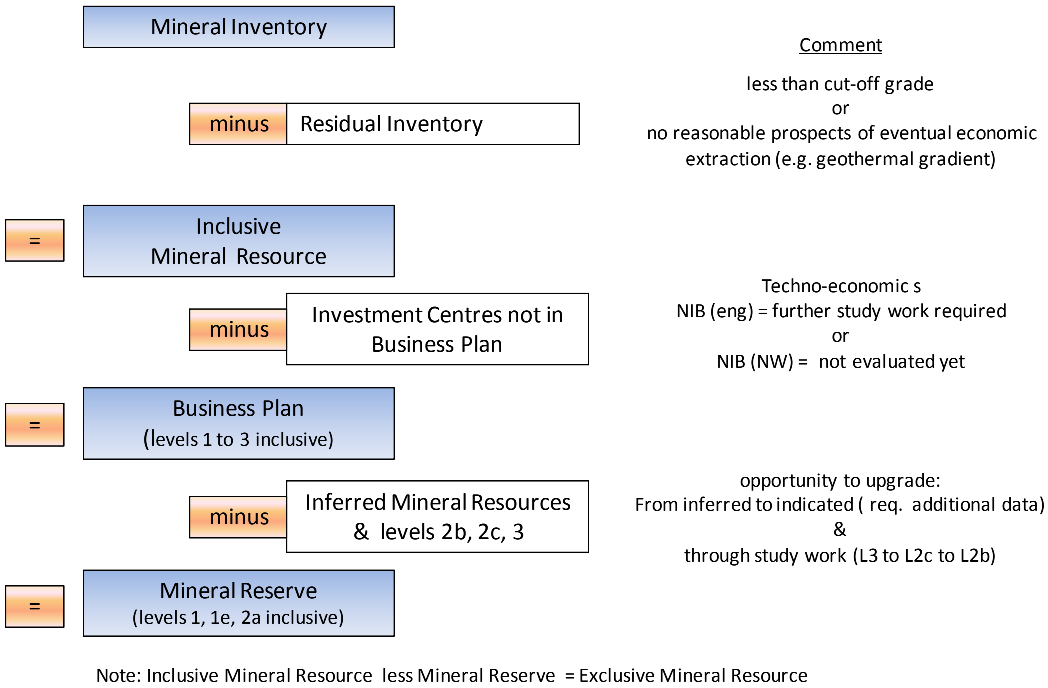


Figure 11.7.7 Schematic relationship of mineral resources and reserves in the business plan context

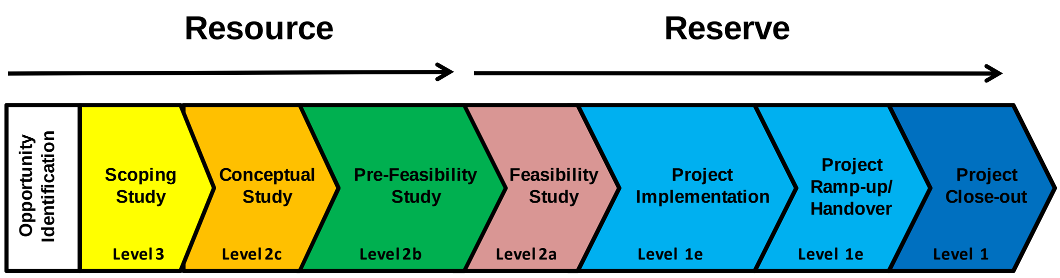


Figure 11.7.8 Resource to reserve – project pipeline perspective

11.7.7 Mining right plan to business plan

The mining right plan (MRP) represents the broader opportunity that is available to the holder of the mining right (the mineral asset). The business plan is that portion, inside the MRP envelope, which is aligned with strategic intent and provides the greatest value. The business plan is used to forecast stakeholder returns, develop proforma financial statements and estimate net cash flows / funding requirements.

Several production and metal price / foreign exchange scenarios, aligned with the world views or scenarios, can be developed for the business plan, with the approved scenario providing the basis for the budget.

Budget

The budget is derived from the first three years of the business plan. The budget encompasses investment centres at level 1 (existing operations not requiring further project capital investment), level 1e (capital projects in execution) and level 2a (feasibility studies) that are forecast to commence execution within the three year budget period.

The budget is developed (updated) annually, based on a 24 month rolling production plan and cost estimate. The three years of the budget are estimated on a monthly basis. The budget is the prime operational management control tool used across the operations.

The relationship between the MRP, budget and business plan

The business plan establishes the optimal extraction sequence for the mining right area, based on a set of prevailing macroeconomic and planning assumptions – it is a full economic and technical plan that indicates the optimised extraction sequence selected from the mining right plan, which is itself aligned to the mining extraction strategy. The core relationship between the portfolio of investment centres in the mining right plan and the business plan are indicated in Figure 11.7.9.

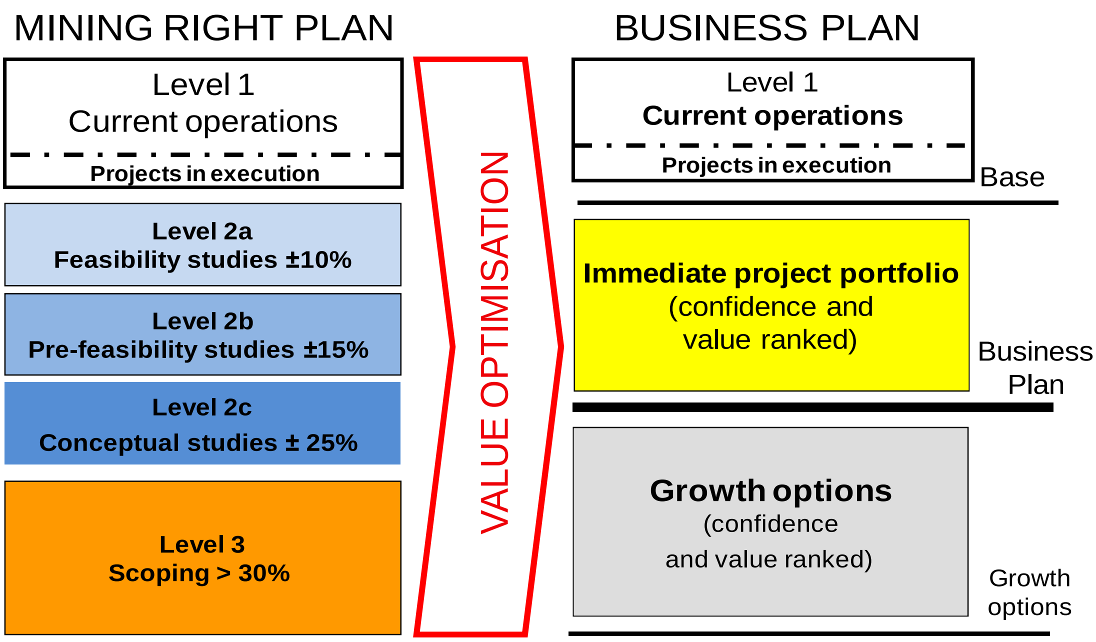


Figure 11.7.9 Relationship of mining right plan to business plan

The mining right plan represents the potential of the mining right area and as such is a portfolio of production plans that defines a possible project pipeline. Following value based optimisation the MRP portfolio of investment centres is prioritised into three plans:

The base plan is the level 1 plan (inclusive of projects in execution) plus any necessary investment to secure mineral right tenure. This is a core plan that indicates what the potential of the company is without any major expansion or replacement projects. It defines a minimum life and return for stakeholders assuming no further investment in major expansion or replacement projects.

The business plan is the plan upon which the budget has been defined. It reflects the base plan plus selected projects out of the unapproved study phase (level 2a, 2b and 2c) categories that meet the required investment returns, strategic objectives and are within the capital funding capacity of the company.

The growth plan comprises both the base and business plan plus selected projects that are aligned with the company strategy but are not currently fundable or require significant further technical work before approval can be granted. Projects in the growth plan subset are predominately scoping studies (level 3 plans). Projects can move from the growth plan to the business plan following the necessary technical and financial approvals subject to availability of capital. The growth plan fundamentally indicates the full potential of a mining right area and, when aggregated across a mineral asset portfolio, the full potential of the company assuming no technical or financial constraints.

11.7.8 Corporate governance

Good corporate governance is achieved primarily through data validation and process auditing techniques, coupled with business continuity risk assessment. Validation and auditing of the various components of the business plan meet the following requirements:

- Good business practice – the application of due diligence and corporate governance;
- Group consistency – a requirement of the Turnbull report (1999);
- Mitigation of risk – review of issues may pre-empt negative occurrences;
- Quality assurance;
- Identification of skills shortage and training requirements; and
- Skills development function.

Another key component in validation is the single point of accountability for data integrity, control and reporting. The entire process is structured to pass on only validated authorised data from one component of the planning sequence to the next.

Auditing of the business planning process is effected through both a single discipline review aimed at testing the individual disciplines and the processes through which planning data is determined and reported. This is followed subsequently with a multi-disciplined review of the consolidated business plan. The multi-discipline review is aimed primarily at assessing the technical content, achievability, practicality, continuity, cross-discipline and cross-functional integrity, and ownership of the plan.

A qualitative risk assessment to record the issues of threat to achieving the business plan is carried out in conjunction with the multi-discipline reviews. Additional issues highlighted by the array of disciplines represented in this forum are added to the issues collected from other risk assessments and consolidated in a central risk database used for Turnbull reporting (1999).

11.7.9 Contribution to the Conceptual Framework

The overall objective of the long term planning processes is:

- To create alignment of activities to a common company planning calendar;

- To ensure utilisation of common logic and tools to facilitate comparison between operations and options; and
- To generate a common business plan that drives execution of the company strategy

The business planning activity creates a central process around which the business organises planning activities to meet the needs of the executive and the Board. It creates an annual rhythm to activities, so that all parties are aware, through the 'five Ps' (Philosophy, Programme, Process, Product, and People) of what must be done, by who, by when and to what standard to meet the company planning needs.

Definition of the long term plan for a mining right and, ultimately the business plan, as the consolidated, optimised view of the mineral asset portfolio, is dependent on following a sequence of activities (see Figure 11.7.1). Specifically this includes defining the mine extraction strategy (essentially defining the unconstrained potential of the mineral asset), applying a set of constraints (the 'top down goals') that reflect the strategic intent of the company, developing a mining right plan based on these constraints, and then optimising the mining right plan for the short term (the budget period – three years) and for the long term (the long term plan – year four and beyond). At a company level, the consolidated mining right long term plans are further optimised based on VBM principles. The discipline of this approach allows for effective comparison across mining right areas and company level optimisation as necessary.

The introduction of investment centres (IC) as the minimum scale entity for investment decisions ensures that resources are effectively deployed during the planning process. Classification of ICs by confidence of estimate (levels 1, 1e, 2a, 2b, 2c, 3, NIB) further allows effective comparison across operations / assets, and facilitates understanding of life of operation without further investment (the level 1e plan) and mineral resource to reserve conversion (the level 2a plan).

The relationship between the mining right plan and the business plan (see Figure 11.7.9) facilitates understanding between what has been included in the business plan, in its constrained form, versus what potential still exists in the remaining IC portfolio held in the growth options.

The long term plan further provides the basis for resource planning of supporting capability (process, engineering, projects, infrastructure, corporate affairs, finance, marketing and human resources) into the business plan.

11.8 Contingency planning

11.8.1 Introduction

Contingency planning identifies a controlled trajectory toward reduced or increased output relative to that originally planned in the long term plan and the business plan. Changes in output are likely to be necessitated through radical market shifts, i.e. a shift to a different world view ahead of the expected timeline. Typically downside shifts are rapid and brought about by crisis whilst upside shifts tend to be more gradual as markets tend to expand at a sustainable growth rate driven by capital cost and availability. Emphasis in this work is placed on the downside scenario which has been termed 'Plan B', although the logic is equally applicable to an upside scenario.

11.8.2 'Plan B'

'Plan B' actions are a sequence of logical steps to move toward a lower future output profile from both current operations and future investments. These are evaluated by investment centre and downscaling options may include close, delay or mothball.

Three primary factors are used to drive the prioritisation of potential 'Plan B' actions:

- The market price for platinum (and the associated full basket of metal prices) at which each investment centre becomes NPV break-even;
- The working cost to revenue ratio for each investment centre as a measure of cost efficiency. This measure ensures that differences in the basket of metals by investment centre are considered; and
- The potential mine output over the following five years.

In addition, a number of further factors are used to help identify 'Plan B' options:

- Dependencies between investment centres and any shared capital expenditure;
- Strategic factors including potential impacts on mining rights or ability to meet BEE requirements;
- Investments required to ensure that future mine economics are sustainable;
- The ability to effectively mothball investment centres and restart operations should market outlook improve; and
- The potential to reduce fixed cost and the overall impact on the financials.

The development of these priorities requires input from multiple parties including the operations, projects, processing and planning.

Annually a 'Plan B' is developed as part of the long term planning process.

The key steps in developing 'Plan B':

1) Planning issues 'Plan B' procedures / guidelines, as part of the LTP, to the operations in January each year.
2) Operations (mine and projects) assess, on local basis, the optimal downscaling sequence of investment centres. These are submitted to the Strategic Long Term Planning department as a list with indication of dependencies and clear explanation of rationale. The relevant financial / project managers prepare a forecast of the expected financial impact of each closure/delay. Both must be submitted at the multidiscipline review.
3) Planning aggregates the LTP submissions and performs the analysis required to rank the investment centres on a matrix. Components of this calculation include, break-even price, working cost to revenue ratio, expected short term (five year) average mine output, year of first production and significant capital expenditure outlays for any project not producing ounces in the following five years. The analysis is completed together with the first consolidation of LTP submissions (interim LTP).
4) Downscaling options are identified by Planning and then revised and agreed with the head of mineral resource management. This identification is on the basis of operational sequencing submissions, discussed in the second point above, in conjunction with SLTPs matrix analysis.
5) Once 'Plan B' actions are identified Planning collates the financial impact analysis provided by the mines. Concurrently processing capacity requirements under a 'Plan B' scenario are reviewed and the impact on operating costs and capital expenditure assessed.

11.8.3 Operational 'Plan B' submissions

<u>Deliverable</u>

The operations (mines and projects) are responsible for submitting their downscaling sequence. This is a list proposing the order of investment centre downscaling priorities within a mine or project (whether to close, delay or mothball). This list needs to indicate the rationale and the dependencies between investment centres. Furthermore, the operations are responsible for providing a high level analysis of the financial impact of the downscaling options.

Key considerations

The rational required is a clear explanation of the reasons for the particular sequence submitted. This considers financial performance, including cost efficiency and NPV, remaining life of mine output, strategic importance (retention of mineral rights, necessity of Merensky proportion), restart flexibility and dependencies with other projects.

Dependencies between investment centres assess the reliance of one investment centre upon the other. This can be of an operational nature; the completion or existence of one investment centre may be required for the existence of another, such as a level 1 project in execution needing to exist for the development of a dependent level 2a project on the same shaft. Dependencies can also be of a cost nature, where the overhead cost sharing of one investment centre with another is crucial to the financial viability of both. The notion of dependencies is expected to lead to some downscaling options being looked at in groups, such that it may only make sense to downscale a group of investment centres together and the corresponding impact in ounces is the sum of these investment centres ounces. Conversely, some investment centres are largely stand alone on an operational and financial basis and so have no dependency worth noting. This should also be indicated.

The financial impact analysis conducted by operations needs to consider the capital expenditure, on-mine cost and one-off cost implications of downscaling each investment centre. The on-mine cost implications should reflect both the direct and indirect impact on cost. This financial assessment is provided for each year of the investment centres' lives. Importantly, this analysis needs to be performed only to a level 3 degree of estimate confidence (±30%).

Matrix analysis

Using LTP submissions it is possible to lay out, on a matrix, all the investment centres or investment centre groupings under consideration. This matrix visually represents their financial standing and timing.

On the x-axis is the break-even platinum price, on the y-axis is working cost/revenue, the bubble size is determined by the platinum production output and the year of first output is represented by the colour of the bubble. Lines depicting the long term price forecast and group average cost/revenue are used to divide the diagram into four quadrants. An example matrix is indicated as Figure 11.8.1.

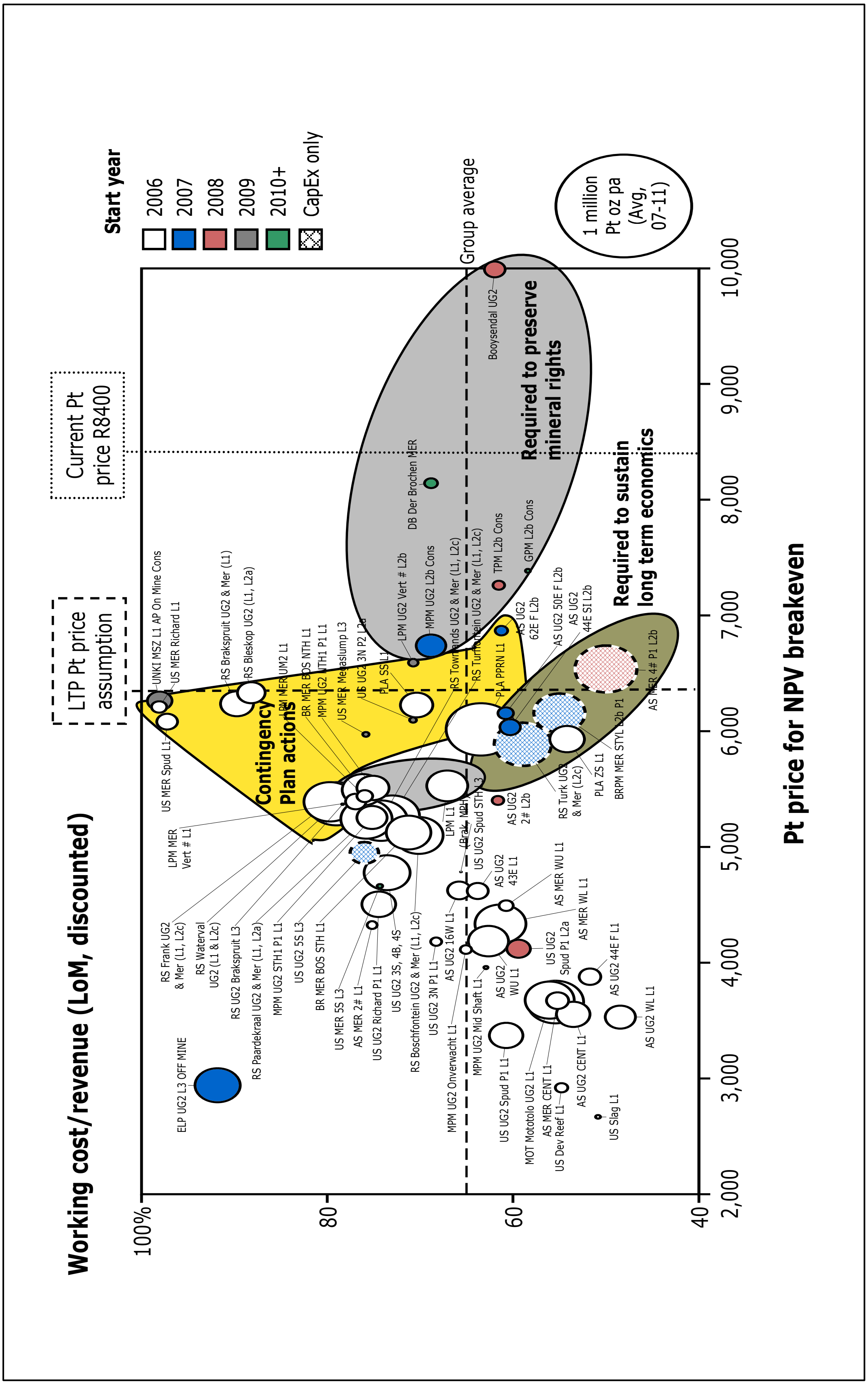


Figure 11.8.1 Example 'Plan B' prioritisation matrix

From a financial perspective, the top right quadrant is the least attractive, bottom right second least attractive, followed by top left and lastly bottom left, the most attractive.

The matrix further allows investment centres to be grouped into distinct categories according to strategic and other considerations. In the example case above, the grey oval contains investment centres in the Eastern Limb, which although unattractive, are necessary for maintaining mineral rights and the olive oval contains those necessary to sustain future economics of the company. This leaves the investment centres in yellow, which are considered in 'Plan B'.

Inclusion of investment centres

To focus the analysis on relevant investment centres their inclusion in the analysis is dependent on three specific criteria:

- Investment centres must be under direct management. Joint venture operations, where the opportunity to influence production is more limited, are excluded from the review.
- Investment centres must be expected to produce platinum over the following five years or require material capital expenditure over those five years.
- Investment centres which have material operational or financial dependencies (as indicated in the operational submissions) must be aggregated into one investment centre, with a recalculation of the metrics as specified in the following sections.

Break-even price metric

The break-even price metric calculates the basket PGM price required for the investment centre NPV to equal zero. This measure indicates the financial sensitivity of investment centres to movements in the basket price.

The calculation of break-even price in Hyperion Strategic Finance (HSF) has three steps:

- Investment centre break-even price is calculated in HSF on an investment centre by investment centre basis. The exchange rate input is flexed, using a goal seek function so that the investment centre NPV equals zero. This implies that the relative ratios of PGM prices remains constant and the price of platinum can be used as a proxy for the basket price. This is done for all investment centres being considered in the LTP.
- Capital expenditure that is not specific to an investment centre is allocated, on a usage basis, to calculate the true break-even point.

- The capital expenditure allocation and investment centre break-even price are added together to calculate the overall break-even price for the Investment centre.

Break-even prices on investment centres that require aggregation for dependencies can be calculated as the weighted average of break-even prices of each of the dependent investment centres (weighted on life of mine platinum ounces).

<u>Working cost/revenue metric</u>

Working cost divided by revenue provides a metric for the cost efficiency of investment centres. This is a more accurate measure of efficiency than cost per platinum ounce because it accounts for the varied PGM and base metal content produced by different mines and investment centres. Working cost is used to ensure inclusion of not only on-mine costs but also off-mine costs incurred in the production.

The calculation uses the life of mine working cost over the life of mine revenue, discounted at current weighted average cost of capital, to get an overall understanding of mine efficiency. The discounting is done to account for the time value of money.
Investment centres that require aggregation for dependencies are treated as one investment centre, where the discounted life of mine working costs are summed as are the discounted life of mine revenues.

<u>Average platinum ounce output metric</u>

Average platinum ounce output provides a metric for the impact on short term ounces delivered to the market. This is a critical metric given that one of the key aims of 'Plan B' is to reduce the number of ounces into the market. The time period selected for this metric is the following five years. This is calculated as an average output per year over the following five years to give an understanding of the potential annual reduction in short term output.

For investment centres that are included because of material capital investment in the following five years (even though they have no output), the average ounce output for the following five year period should be used.

<u>Start year metric</u>

The year of first platinum ounce output is material for determining the immediacy of down-scaling a particular option. The matrix bubbles should be coloured by year of first platinum ounce output.

Aggregated dependent investment centres are dated from the first year of platinum output.

For the investment centres that represent material capital expenditure investment in the first five years without any platinum output, the same colours should be used for start years, only with a different pattern. The start year in this case is determined by year of first capital expenditure.

Deliverable

A set of prioritised actions is identified using the operational inputs and planning analysis. The number of actions chosen depends on the total ounce reduction required. The financial impact of these actions, in terms of working cost and capital expenditure savings, and in terms of potential impact on processing and central services is estimated on the basis of operational submissions and needs to be consistent with LTP data.

A first view needs to be developed using the above process as an input into the scenario planning and strategic review cycle. This preliminary view provides an opportunity for thorough scrutiny of options and is potentially useful information in considering the revised business plan and growth plan scenarios.

Identification

In terms of the identification process, the following steps are applicable:

- Identify particular groupings of investment centres that will not be considered in the prioritisation, such as those excluded on strategic grounds.
- Having reduced the group to a subset, the remaining investment centres can be prioritised on the basis of financial attractiveness, eliminating those in the furthest top right position on the matrix and then moving down and left.
- Where the trade-off is marginal, second order considerations, such as restart flexibility should be used.

Ounce impact

The ounce impact of this prioritisation is calculated as the five year average annual ounce reduction and can be displayed as per Figure 11.8.2.

Currently the downscaling options fall into three tiers:

1) Investment centres currently producing platinum ounces which are marginal;

2) Investment centres which could be delayed to slow growth and postpone capital expenditure; and
3) Investment centres producing platinum ounces which are less marginal but could deliver larger reductions in output.

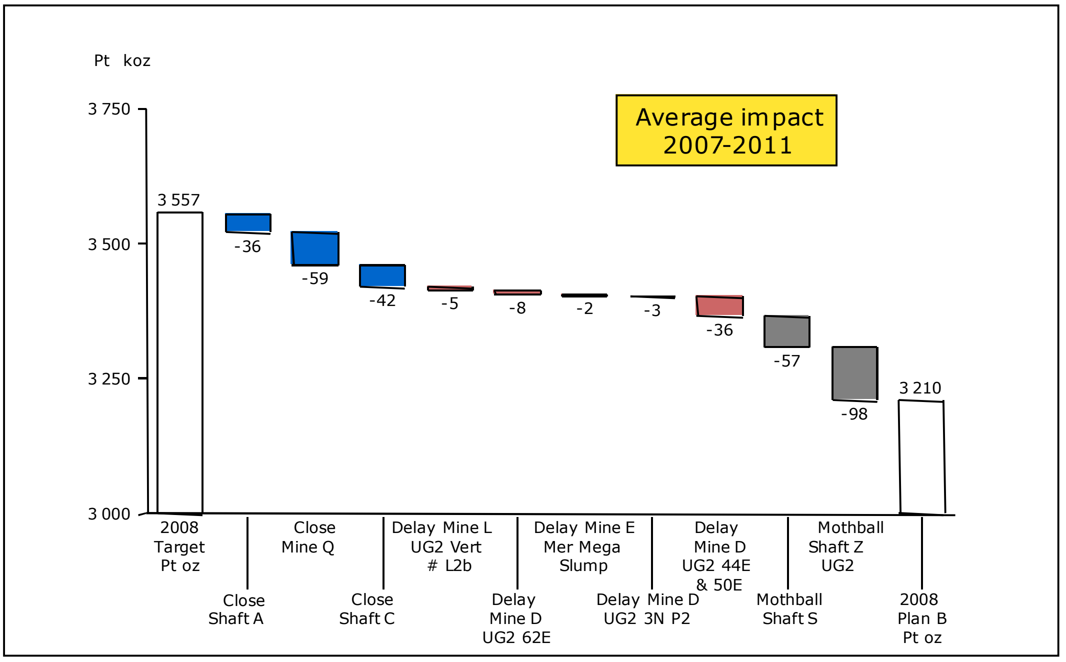


Figure 11.8.2 Example – impact of 'Plan B' on platinum output

11.8.4 Financial impact analysis

A consolidated view of the financial impact of 'Plan B' should be developed.

Four key components need to be assessed:

- Impact on mine, project and processing capital expenditure, calculated as the sum of capital expenditure reductions, both stay-in-business and expansion, as a result of 'Plan B'. For processing, the reduction in throughput is compared to capacity replacement profiles for concentrating, smelting, base metal refining and precious metal refining. The elimination of expansion requirements is seen as a capital saving. The delay of expansion requirements is calculated as the difference in NPV of the investments.

- Impact on on-mine operating costs; the operational submissions of on-mine costs for the identified 'Plan B' actions are aggregated to calculate the on-mine impact. The downscale options are then removed from total mine or project costs to report the revised cost per platinum ounce under 'Plan B'.

- Impact on processing costs; the reduction in processing costs are provided by the processing directorate and are used to report the revised processing cost per platinum ounce under 'Plan B'.

- One-off cost of implementing 'Plan B', is calculated by aggregating operational and processing submissions of one-off costs.

The financial implications are presented as the reduction on capital expenditure and the impact on cost per ounce for affected mines. A sample diagram of this is presented in Figure 11.8.3.

The impact on processing is also evaluated in terms of impact on capital expenditure NPV for smelters, base metal refinery and precious metal refinery and to processing cost per platinum ounce.

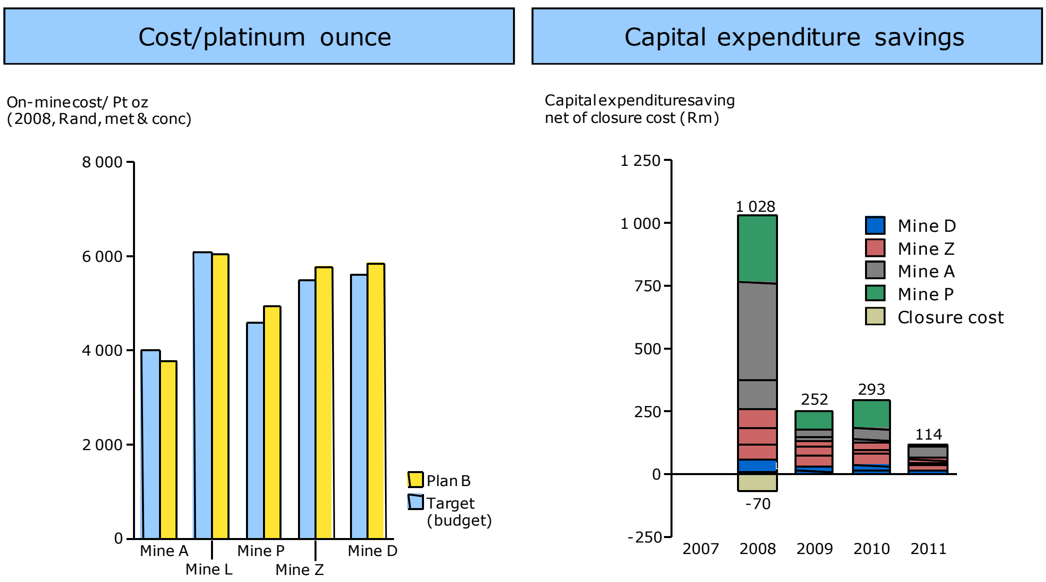


Figure 11.8.3 Example – financial impact of 'Plan B' on operations

<u>Consolidation and final draft</u>

'Plan B' actions and implications are consolidated by the end of the business planning process by the planning department. These are summarised in a written format and incorporated in the strategy review document, as a potential scenario alongside business plan and growth options. The strategy review document is then submitted to the executive committee and the Board of Directors for approval.

11.8.5 Contribution to the Conceptual Framework

Contingency planning is the preparation for an unexpected, rapid shift in industry dynamic. Despite development of world views or scenarios, the rate of change between anticipated world views is difficult to anticipate and usually rapid.

Generation of contingency plans allows a rational, controlled shift between one operating state and the next based on earlier analysis. It is a means of reducing the scale of crisis through anticipation and prior sensitisation.

Contingency planning recreates the link between the business plan (part C) and the world views (part B) by creating an iterative loop based on a different set of global assumptions. This process is real option valuation and drives re-optimisation of the long term plan and the mineral asset portfolio composition in light of a possible alternative world view.

11.9 Valuation logic

Evaluation of overall business performance is typically considered in terms of a range of parameters that seek to answer a basic shareholder question: What return am I getting on my investment?, which will then inform the decision to continue or to disinvest. Typically, consideration is given to return on equity (before and after tax) or earnings per share (after tax) these are in turn impacted by capital gearing (debt/equity ratio).

In essence a business needs to be financially viable, viz. make a profit in the long term but remain solvent in the short term by generating a positive cash flow. Within this context decisions are therefore made on long (and short) term investments and how cash can be raised to finance these investments.

In order to effectively assess overall business performance it is necessary to include all past cash flows in the business; the business performance evaluation should include all ‘sunk’ or ‘historic’ cash flows (including revenues, capital expenditure and costs).

11.9.1 Capital investment decisions

Conversely, the capital investment decision is only concerned with the question: What value will this capital investment add to the business?, which will then inform the decision to make or not to make the investment.

In this capital investment decision, ‘sunk’ cash flows should be excluded, as they have no bearing on the future viability of the investment. ‘Sunk’ cash flows by definition are costs and revenues that have already been incurred and thus cannot be changed by the decision to accept or reject a project.

11.9.2 Discounted cash flow valuation

The generally accepted method of appraising capital investments, when sufficient data is available, is through the use of discounted cash flow (DCF) valuation. A variety of DCF techniques exist, however use is generally made of net present value (NPV) and internal rate of return (IRR) and economic profit (EP). DCF analysis requires consideration of the relevant cash flows that come about as a direct consequence of a proposed capital investment.

The discounted cash flow analysis method of evaluation is a forward looking methodology which requires that forecasts be made with respect to technical and economic conditions which are likely to prevail in the future. All predications of the future are inherently uncertain but the level of uncertainty will be materially reduced if adequate data is available from which to predict the future rates of production, costs (operating and capital) and commodity prices associated with exploitation of the mineral resource to the end of its estimated economically useful life.

The best application of discounted cash flow analysis results from the valuation of an existing mining operation where the mineral reserve has been well defined and extraction has been scheduled over life of mine. From a cost basis, there should be established capital infrastructure accompanied by stable cash costs. For the most part, strategic life of mine plans, for mature operations, are generally undertaken in this guise.

At the next level, discounted cash flow analysis can be used to assess the economic viability of a proposed project based on a reserve estimate, a comprehensive engineering study, detailed estimates of capital investment requirements and rational projections of operating costs and revenues. Since discounted cash flow analysis can be applied to assess the value associated with differing levels of expansion, increases in operating life and changes in mineral resource, it remains the preferred method for valuing various options available to the business. Ultimately, as long as a mineral resource has been identified and it is possible to make a reasoned estimation of production rate, associated costs and revenues, discounted cash flow analysis can be applied. However, cost determination in this instance may be problematic and it is recommended that project costs be estimated based on first principles rather than on an average unit cost (R/t).

Value accretion from individual projects should, however, always be considered in the context of the largest logical decision making unit e.g. a mining complex rather than a single shaft in order to accommodate interdependencies. A project may not necessarily have a positive NPV when evaluated on a standalone basis, however value may be derived from the benefit this project affords the rest of the complex through the sharing of infrastructure and hence the dilution of fixed costs (Ballington *et al*, 2005). Therefore it is pertinent to always evaluate projects on the basis of incremental benefit to an operation and not solely on the project cash flow.

The generally accepted methods of appraising capital investments, when sufficient data is available (pre-feasibility through to operational expansion), are those that incorporate annual cash flow projections and recognise the time value of money, particularly net present value (NPV) and internal rate of return (IRR). Within this context NPV is initially applied to capital investment decisions with later application as a guiding principle throughout the mine planning process as the principal determinant of value assessment. The realisation that planning options that demonstrate increments in value have the potential to create value for the business and are generally cumulative, has rapidly lead to the concept of value maximisation or optimisation of strategic mine plans, with the term optimisation largely coming to mean maximisation of plan NPV in the minerals industry (Ballington and Smith, 2002).

Discounted cash flow analysis provides a means of relating the magnitude of all expected future cash flows to the magnitude of the initial cash investment required to purchase the asset and develop it for commercial purposes. The objective of discounted cash flow analysis is to determine:

- The net present value (NPV) of a stream of expected future cash flows; and
- The rate of return (IRR) which the expected future cash flows will yield on the original cash investment.

It is important to note that NPV and IRR are interrelated, with the IRR being the rate at which the NPV of the capital investment is zero. IRR has a critical limitation in that it can only be reliably calculated for a conventional investment cash flow, viz. investment outflow/s followed by returns. Non-conventional cash flows result in multiple IRRs, which are misleading.

An investment is considered to add value when NPV > 0 and IRR is greater than the company specific investment hurdle or discount rate. Larger NPV and IRR values indicate better returns and inherently lower risk. NPV and IRR should be considered in concert rather than independently. Hurdle rates are determined by considering a variety of risks –

operational, project and country in addition to the weighted average cost of capital, and will change dependent on the scenario or world view context that is applied.

Mineral resources are a finite, non-renewable resource. The optimum exploitation strategy therefore needs to be dynamic due to the continual changing of commodity prices, rate of extraction and life of mine over time.

The seemingly competing objectives of maximising profit and maximising extraction are constrained by the spatial characteristics of the orebody and extraction technology. Trade-off studies to evaluate the scale of operation will tend to focus on maximising the production rate that can be sustained by the orebody geometry. The use of discounted cash flow analysis allows for the impact of varying price regimes over time and at real discount rates of 8% - 15% ensures that the value created beyond 30 years into the future has little impact on the overall value construct.

The economic life of mine for a mineral resource is thus a key decision variable which is largely driven by the rate of extraction, with the optimum strategy encompassing the entire resource. The optimal strategy should be focused on exploitation of the entire resource so as to maximise the present value – the challenge is however to find the optimal trajectory which achieves the maximum as conditions vary over the life. In other words, maximising value over time requires the optimisation of each subsequent extraction step in an environment with continual changes in market perspectives and operating conditions.

Despite criticism, the use of DCF analysis is likely to persist in the minerals industry in the foreseeable future. From a strategic planning perspective, the absolute value of net present value should not be considered as the final investment decision criterion but rather as a key indicator to be assessed in conjunction with other factors. Further, the relative value of differing scenarios is more informative than the absolute value of each scenario.

Relevant cash flows

DCF analysis requires consideration of relevant cash flows – cash flows that come about as a direct consequence of the proposed capital investment. These are indicated in Table 11.9.1.

Table 11.9.1 DCF – components of relevant cash flow

EXCLUDE	INCLUDE
• Sunk or historic costs • Financing costs • Investment income	• Revenue • Cash operating cost (direct, indirect) • Stay-in-business capital • Initial project capital (expansion or replacement) • Working capital changes • Taxation • Secondary tax on companies • Royalties

Money terms

Considerable confusion arises regarding money terms. It is however a simple case of adjusting for the effect of inflation. A nominal money term figure contains an inflation component whereas a real money term figure does not.

The following is a broad guide to terminology that is used:

- Nominal terms:
    - o includes the effect of inflation;
    - o “money of the day”;
    - o “escalated”; and
    - o “current”.

Budgets are usually reflected in nominal terms.

- Real terms:
    - o excludes the effect of inflation;
    - o “money today”;
    - o “de-escalated”; and
    - o “constant”.

The long term plan (LTP) is reflected in real terms.

It is important that cash flows are initially calculated in nominal terms, so that taxation can be computed and included, prior to de-escalating to real terms for discounting to present values.

This is achieved, in the modelling environment, by inputting values in real money terms (regardless of when in the future the income or expense is to occur) and allowing automatic escalation (different rates for revenue, cost and capital) to nominal terms. The calculated nominal cash flows can then be de-escalated back to real terms, and finally discounted allowing for a calculation of NPV at an appropriate real discount rate.

Discount rate

The discount rate or hurdle rate or cost of capital is the rate used to calculate the present value of future cash flows. A tiered series of discount rates, depending on the risk associated with the proposed project, can be applied to cash flows in real money terms in order to determine the real NPV.

Typically the rates would comprise:

- A base rate (typically weighted average cost of capital) or operational or stay-in-business risk;
- Plus a country risk rate;
- Plus either:
    - A 1 % brownfield project risk rate, or
    - A 2 % greenfield project risk rate.

A real discount rate is used because:

- Most investment evaluation assumptions will be developed initially in real terms; and
- By applying a real discount rate to real cash flows, the risk inherent in nominal term valuations (i.e. the mismatch between the inflation rate assumed in the derivation of the discount rate and the inflation rate assumed in the cash flow projections) is avoided.

The recommended hurdle rate should be used to discount real cash flow estimates net of full corporate tax, which must be unbiased, i.e. have equally-weighted upside as well as downside. These discount rates should be assumed to include the tax benefits of debt financing and these should not be calculated separately.

Long term economic and planning parameters (global assumptions)

Long term economic and planning parameters encompassing assumptions on exchange rates, metal prices, inflation, capex and opex (on and off mine costs) escalators, process division assumptions, etc. are provided by Planning, updated and released quarterly. These are termed the global assumptions. No variation from the approved issue of global assumptions is permitted.

The global assumptions provide a generic view for a company on the different capital and operating cost escalator forecasts. The need may arise on a specific project base to modify the escalators used in the investment modelling valuation, possibly for example due to an abnormally high percentage of the capital cost of a project being influenced by exchange rates, e.g. steel, tyres, etc. This issue should be discussed and agreed upon by the project manager and project team, in consultation with Planning before changes are implemented. Occasionally, when third parties are involved (such as joint venture (JV) negotiations) a consensus global assumptions model is formed between the parties for the specific use by the JV in determining the value of the capital investment.

Long term planning level categories

The structuring of a mining right plan (MRP) and business plan can be illustrated in the conceptual diagram (Figure 11.9.1) below, reflecting the production profile of an operation, together with its associated project pipeline.

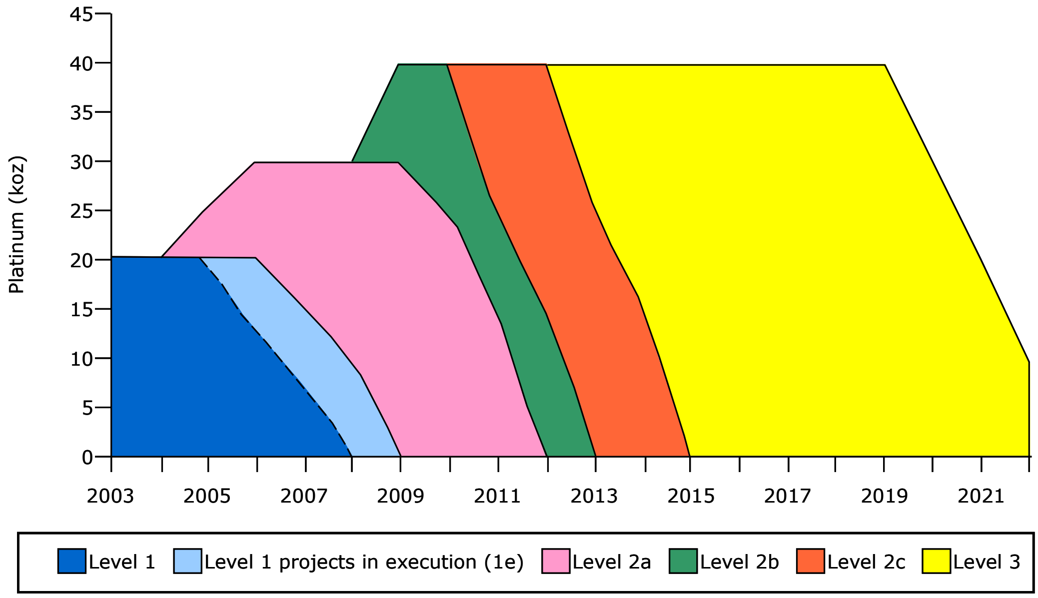


Figure 11.9.1 Relationship of long term planning level categories for an operation

The MRP for an operation consists of a number of investment centre models that comprise varying levels of confidence as indicated in Section 11.7.

Project pipeline process

The development of an identified opportunity through the various project phases and review stage-gates into an approved capital investment is illustrated in the schematic Figure 11.9.2 reflecting the project pipeline process.

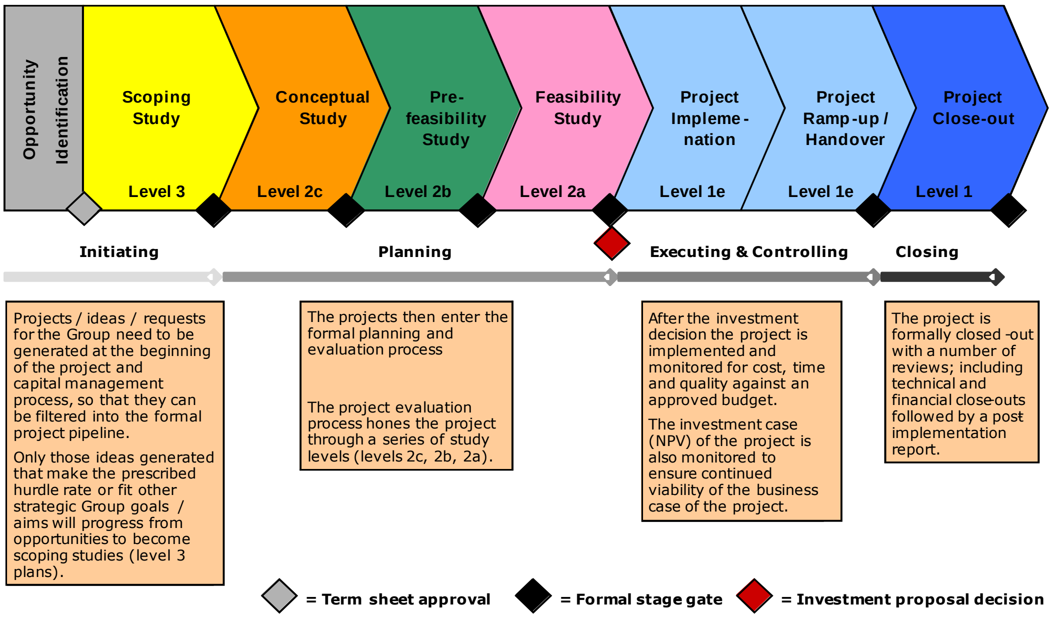


Figure 11.9.2 Project pipeline process

Capital investment categories

Capital investments (see in Section 11.7) are broadly divided into categories of Projects (or proposed capital investments) and Stay in Business. The purpose of this classification is to provide a more meaningful distinction between capital expenditure which is in the normal run of business (typically relating to existing assets and likely to be relatively stable from year to year), and significant projects which are one off, and serve to expand or maintain total business capacity through the exploitation of new sites or near-mine sites.

Projects (or proposed capital investments)

The following categories apply:

- Expansionary projects: no minimum value of project is set, but expansionary projects will in practice involve only material increases in production rather than small-scale capacity creep.

- Replacement projects: their primary objective is to replace capacity lost due to the decommissioning or working out of an existing production unit, thereby maintaining the overall level of capacity. Replacement projects will typically involve a collection of assets that together represent a discrete new income generating unit, although the new unit may share certain infrastructure with existing production units. Replacement projects would therefore not include replacement of individual assets such as haul trucks, loaders, or capitalised rebuilds of existing equipment, which should be included in the stay in business capital category.

Stay-in-Business (SIB)

This comprises capital expenditure undertaken in order to maintain the life of existing assets without materially increasing capacity and includes:

- Replacement or capitalised rebuild of individual assets such as vehicles, machinery, plant, etc.
- Ore reserve development; and
- Capital expenditure undertaken primarily for non-financial reasons, such as safety, health and environment capital expenditure.

On-mine cash operating cost categories

Figure 11.9.3 below illustrates how the various components of on-mine cash operating costs are related.

Total operating costs	Total cash operating costs		On-mine cash operating costs			
comprise of:	comprise of:	components are:	comprise of:	components are:	components are attributable either:	Attributable components comprise of both:
Labour	Labour	On-mine	Shafthead	Direct	Directly	Fixed
					Apportioned	Variable
Stores	Stores		Concentrator	Direct	Directly	Fixed
					Apportioned	Variable
Contractors	Contractors		Central Services	Indirect	Directly	Fixed
					Apportioned	Variable
Utilities	Utilities	Off-mine	Smelting			
			BM Refining			
Sundries	Sundries		PM Refining			
			Other			
Amortisation						

Figure 11.9.3 Components of on-mine cash operating costs

Shaft head costs

Shaft head costs are cash operating costs that are attributable to the mining activity portion of the on-mine cash operating cost.

They may be:

- A single direct cost such as a stoping or development cost associated with a half level; or
- They may be mining overhead costs, shaft overhead costs and shared mining costs that may need to be apportioned on a tonnage allocation basis.

They are generally composed of fixed and variable cash operating cost components and should reflect step changes to the fixed/variable ratio when necessary.

Concentrator costs

Concentrator costs are cash operating costs that are attributable to the concentrating activity portion of the on-mine cash operating cost, and may be attributed on a tonnage allocation basis if the concentrator serves more than one shaft.

As with shaft head costs, concentrator costs may be:

- A single direct cost such as a steel ball load cost associated with a plant; or
- They may be shared concentrator costs that may need to be apportioned on a form of tonnage allocation basis.

They are generally composed of fixed and variable cash operating cost components and reflect step changes to the fixed/variable ratio when necessary.

Central services costs (indirect costs)

Central services costs are cash operating costs that are indirect costs attributable to the on-mine cash operating cost. They are therefore attributed on a form of absolute Rand allocation basis after the combined annual Rand amount of shaft head and concentrator costs for the total mine complex has been established. They are often determined at both a local and group level.

They are generally composed of fixed and variable cash operating cost components and should reflect step changes to the fixed/variable ratio when necessary.

<u>The effect of multiple proposed capital investments</u>

At an operating unit if there are multiple simultaneously proposed capital investments (projects) that form part of the project pipeline (study levels: feasibility (2a), pre-feasibility (2b), conceptual (2c)) as outlined in the approved mine extraction strategy and associated LTP; and these are reasonably likely to be approved by the prerequisite boards and technical committees then both the concentrator (tonnage allocation basis) and central services (absolute Rand allocation basis) costs that have been calculated for the complete operating unit assuming that all of these projects proceed; should then be allocated (on the appropriate basis) back to each 'base case plus optimised investment model' for each of the proposed capital investments.

11.9.3 Capital investment decision – modelling philosophy

Capital investment decisions should be conducted on an incremental cash flow, stand-alone basis, with the assumption that all available profits are paid out, viz. only the cash flows attributable to the proposed capital investment are therefore considered. This is readily achieved on greenfield projects but extremely difficult in brownfield investments, as it is often not possible to effectively separate the incremental cash flows. Joint ventures (JV) would, from a valuation modelling and data integrity point of view, be handled as per any other proposed capital investment.

A further complication is the use or exclusion of the tax base available from the cash flows from the existing operations. Mining companies are entitled, in terms of current tax legislation, to redeem capital expenditure in the year that it occurs. In the event that profit is inadequate to redeem the capital expenditure, the unredeemed portion is carried forward to the following year. The tax shield derives from unredeemed capital expenditure or an assessed loss, which may have accumulated in the tax entity. Use of a tax shield effectively increases the cash flow as tax is not paid until all unredeemed capital expenditure and assessed losses have been offset against taxable income.

Owing to varying operational structures, relative to tax entities, it cannot be automatically assumed that all projects will receive the benefit of a tax shield. Valuation of an investment decision must therefore be considered with and without the benefit of a tax shield.

Owing to the process of approval of interim votes (IV) and conditional interim votes (CIV) it is necessary that model timelines and assessments be consistently based on project phases as indicated in the investment proposal. It may therefore be necessary to include a cash flow adjustment in the first year of the models for cash flows (revenues (+ve) and capital expenditure and costs (-ve)) that have resulted from interim votes or conditional interim votes to facilitate comparison. These manual adjustments must be money term corrected (e.g. adjusted by inflation to the correct year), and discount/hurdle rate corrected to the relevant input year for HSF (e.g. adjusted by the Anglo Platinum cost of capital).

Figure 11.9.4 indicates the relationship of the capital investment decision and business performance models.

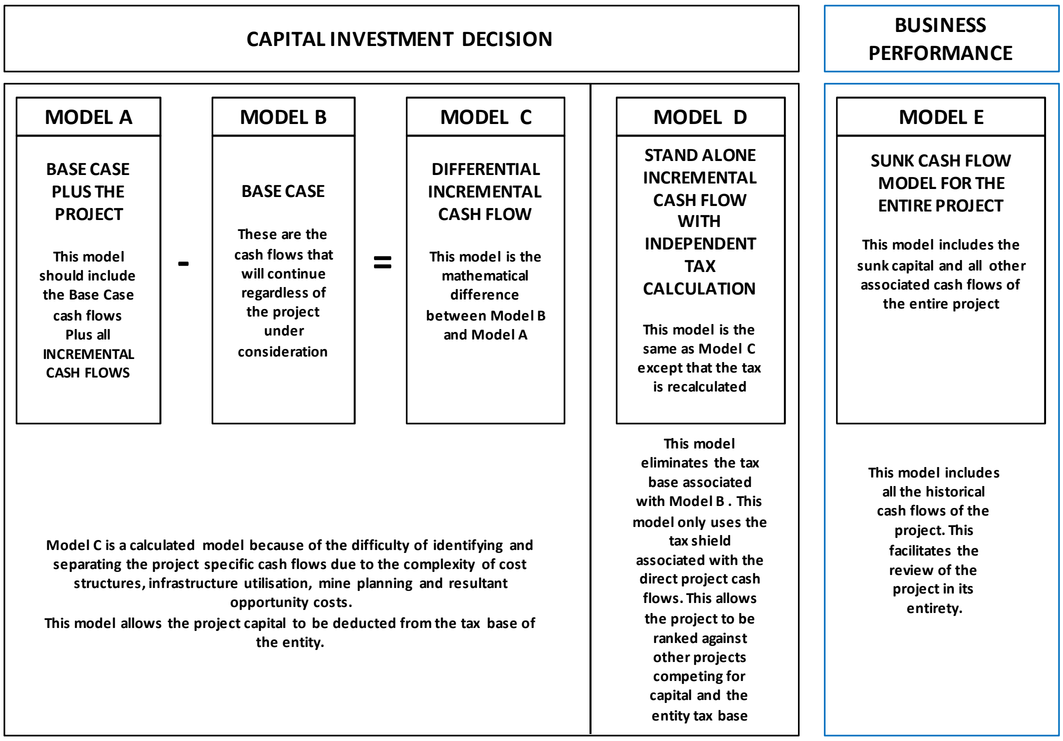


Figure 11.9.4 Relationship of capital investment decision models

On this basis the following philosophy should be applied in modelling the capital investment decision using DCF, for greenfield and brownfield projects:

<u>Greenfield projects</u>

- Stand-alone cash flows; and
- Exclude tax shield benefit – model as stand-alone entity with no company tax shield benefit from other entities.

Special consideration of taxation aspects (e.g. ring fencing) will be necessary for greenfield projects being developed in conjunction with third parties e.g. JVs, pooling and sharing agreements, etc. Tax structuring should be optimised in all cases but not used to justify an investment. Referring to Figure 11.9.4, a greenfield project would be represented by Model A, as Model B would not exist.

Brownfield projects

Owing to the complexity and inter-relationship of cost components it is necessary to develop a range of models to identify the incremental cash flows, and associated value, arising from the proposed capital investment. These models are the base case, base case plus optimised investment and the incremental model.

Base case model

This model represents the latest state of the operating business within the mining right boundary area as defined in the MRP, which has in turn been derived from the approved mine extraction strategy (MES) and reflected in the business plan at level 1. This model should:

- Have all the costs that are generated as a result of the operating business allocated on a full absorption costing basis between the cost generating units (e.g. shafts, concentrators, etc.) either directly or indirectly on some form of allocation basis for the operation as a whole;
- Include the necessary royalty payments (which may vary between farms and beneficiaries) and secondary tax on companies (STC);
- Include levels of stay in business capital expenditure necessary to maintain operations prior to closure;
- Have the fixed/variable cash operating cost structure constructed from first principles (or a zero based cost), with reference to a relevant benchmark and constructed in conjunction with a back analysis of existing and/or similar operation management accounting data if applicable;
- Have the cash operating cost structure (for shaft head, concentrator and central services costs) reflect an increase in unit cash operating costs as a result of declining production associated with no further capital investment, i.e. step changes to the fixed/variable ratio in the latter years of production;
- At the appropriate time when cash flows from the operating business are negative on a continuous basis (i.e. uneconomic), have the reduced production curtailed, i.e. production tail management; and
- Include closure costs associated with the potential closure of the operation should no further investment occur.

The base case model should reflect, as realistically as possible, the position that the operating business is in prior to the proposed capital investment, and is represented by Model B in Figure 11.9.4.

Base case plus optimised investment model

This model represents the state of the operating business including the proposed capital investment within the mine lease boundary area as defined in the MRP, which has in turn been derived from the approved mine extraction strategy (MES). This model should:

- As a result of the proposed capital investment generate a new production and cost profile for the operation as a whole, which aligns with and is outlined in the approved mine extraction strategy (MES);
- Include the necessary royalty payments (which may vary between farms and beneficiaries) and secondary tax on companies;
- Include levels of stay in business capital expenditure necessary to maintain operations prior to closure following the proposed capital investment;
- Have the fixed/variable cash operating cost structure constructed from first principles (or a zero based cost), with reference to a relevant benchmark and constructed in conjunction with a back analysis of existing and/or similar operation management accounting data if applicable;
- Have the cash operating cost structure (for shaft head, concentrator and central services costs) reflect anticipated changes in unit cash operating costs as a result of sustaining or increasing production, followed by a subsequent increase in unit cash operating costs as a result of declining production associated with no further capital investment, i.e. step changes to the fixed/variable ratio in the latter years of production;
- At the appropriate time when cash flows from the operating business and proposed capital investment are negative on a continuous basis (i.e. uneconomic), have the reduced production be curtailed; and
- Include closure costs associated with the potential closure of the operation following the proposed capital investment.

The base case plus optimised investment model attempts to represent the position that the operation will be in as a result of the proposed capital investment and is represented by Model A in Figure 11.9.4.

The accuracy of this representation will be a function of the level of confidence of the estimate associated with the proposed capital investment (or project) in terms of the amount of unapproved capital expenditure that may be required and the technical accuracy of the data available.

Incremental model

This model is the difference between the base case plus optimised investment model and the base case model. It can be obtained through consolidation in HSF.

It is therefore the incremental costs that are generated by the proposed capital investment over and above those that existed in the base case (i.e. if the mine central services costs in the base case model were R100 million, and with a proposed capital investment the central services costs for the operation increase to R120 million, then the proposed capital investment is liable for the incremental increase of R20 million).

Two variants must be developed and these models allow identification of direct value arising from the proposed capital investment and the extent of the use of the tax shield in the overall creation of value.

- Differential incremental – inclusive of the entity available tax base
    - This is the model that results from a normal consolidation, and is represented by Model C in Figure 11.9.4.
    - It is a differential model and <u>does not</u> recalculate tax. It calculates the differences in the free cash flows.
    - This model is used if Model A and Model B have a tax base and there are no other capital investments competing for that tax base.
- Stand-alone incremental – exclusive of the entity available tax base
    - This model utilises the tax shield associated with the proposed capital investment, and is represented by Model D in Figure 11.9.4.
    - It does not receive any tax benefit by deducting the proposed capital investment from cash flows associated with existing operations.
    - It takes the differential cash flows on profit before tax and recalculates the tax and STC on these cash flows (it taxes the cash flows as an entity on their own).
    - It is used where the quantum of the available tax base is uncertain (either due to the uncertainty of the taxable income at the level of the taxed entity or the competition of other proposed capital investments).
    - This model also allows for comparison and ranking of investment options across the company / organisation.

11.9.4 Business performance – modelling philosophy

Outside of the capital investment decision is the need to assess aspects of overall business performance. This can be undertaken in two ways.

<u>Sunk cash flow model</u>

A further model can be constructed, which represents the net position of the full investment in the project or business entity to date. This model is effectively the base case plus optimised investment model with an adjustment for sunk cash flows (revenues (+ve) and capital expenditure and costs (-ve)) prior to the proposed capital investment, and is represented by Model E in Figure 11.9.4. This model should:

- Include, money term corrected, cash flows attributable to the investment (e.g. all sunk costs should be adjusted and re-expressed in real money terms that match the input money terms of the valuation model), relating to:
  - Revenue (actual business attributable not transfer pricing);
  - Cash operating cost; and
  - Capital expenditure.

<u>Project value tracking analysis</u>

Once the capital investment decision has been made the business investment performance tracking and monitoring of the approved investment proposal is of crucial importance for company management, as periodic reviews will allow pro-active rather than re-active steps to be taken to address any deviation from the expected business case. This is effectively the systematic tracking (variance analysis) of the business case value of a project between two points:

- Generally the original view baseline model forecasts for the project undertaken at the point of the capital investment decision; and
- The present perspective for the project, which encompasses the actuals achieved to date and the latest future view forecasts for the project.

Project value tracking (PVT) analysis takes the form of a waterfall chart, which illustrates the relative importance of various external (environmental variables) and internal (management levers) factors that have caused the NPV to change since the original view baseline model.

<u>Comment</u>

The complexity and nuances of individual capital investment decision valuations need to be considered and approaches developed that are consistent with the overall philosophy. Consistency of approach improves communication with decision making entities. Any variation from the overall approach therefore needs to be identified, rationalised and agreed to prior to presentation to decision makers.

In order to assure consistency of modelling computation and provide an effective audit trail, the valuation of strategic long term planning scenarios is conducted, on a discounted cash flow (DCF) basis, using a specific software application – Oracle Hyperion Strategic Finance (HSF). HSF is used to perform valuations and assess capital investment decisions, and to run, consolidate and produce the organisation's long term plan (LTP). See Marsh *et al.* (2005).

The application has been highly customised to meet company requirements through which formatted technical input data (tons milled, head grade, plant recoveries, operating expenditure (opex) and capital expenditure (capex)) is coupled with a set of long term macroeconomic and planning parameters (Rand-US dollar exchange rate, consumer price index percentages, opex and capex escalation percentages, metal prices and process division assumptions) to perform a DCF analysis on a series of calculated annual cash flows. The modelling starts at an investment centre (IC) level, i.e. reef type per shaft and is consolidated at shaft, mine and group level as required (Marsh *et al,* 2005).

11.9.5 Real options – logic and application

Mineral asset investment opportunities invariably have managerial flexibilities (real options) embedded into current and future project portfolios. The greater the managerial flexibility, the greater is the value of the investment opportunity, in a changing business environment.

The cyclical, mineral asset characteristic based, market aligned, business need driven, process of strategic long term planning creates opportunity to exercise managerial flexibility at regular intervals in response to changing market and economic conditions – the essence of real option valuation logic.

In the mineral industry the key choices that can be made in terms of mineral asset utilisation, relate to decisions around:

- Maintaining current output by reinvestment into existing production sources and facilities: Assuming dynamic grade optimisation, this implies a need for continuous technology and cost improvement to avoid progressive movement up the cost curve.
- Expanding output from existing production sources and facilities: This approach will result in a shortened life of mine but allows volume based optimisation.
- Development of new production sources and facilities: This assumes that there are alternate or unutilised opportunities within the mineral asset portfolio that can be utilised.

- Temporary suspension of some or all options (mothballing of facilities): This entails progressive removal of less attractive production entities or slowing down of projects in execution.
- Reopening suspended production sources: This implies the resumption of previously suspended operations – either in their previous form or with the adoption of new working practices and/ or technologies.
- Abandonment of production sources (disposal): The mineral asset portfolio is reduced based on existing or anticipated performance.

For most capital investments in the minerals industry, timing of action is the primary option that can be considered. This is especially the case with large sunk cost investments such as shaft infrastructure.

The progressive development of a mineral asset from acquisition of a prospecting licence, exploration activities through to final project development and production can be viewed as a series of sequential or compound options. The acquisition of a mining right gives the option to establish a prospecting right; investment in exploration creates an option to exploit the mineral asset; investment in project studies creates an option to move from one level of study estimate to the next and ultimately to project execution; project execution creates options to accelerate / slow down execution rate; and finally creates choices on expansion / contraction / mothballing / disposal.

Within this overall project evaluation and implementation process, uncertainty creates the option for managerial action. Broadly two types of uncertainty exist; economic and technical.

Economic uncertainty is related to global economic movements (metal prices, exchange rates, escalation rates), is exogenous to the project and impacts the revenue component of the investment decision. This uncertainty can be resolved by waiting or delaying investment. However owing to the long lead time of the majority of mining projects and cyclicality of minerals and metals markets, mistiming of production is likely. Economic uncertainty impacts the industry equally, rather than specifically. In the strategic long term planning framework, economic uncertainty is encompassed in the development of scenarios or world views.

Conversely technical uncertainty is specific to the mineral asset being exploited, mining layout and design (technology) selection, scale of operation, operating philosophy and the resulting operating costs. Technical uncertainty is resolved through incremental or sequential investment in the mineral asset (exploration, project studies, trial mining, etc.).

This process creates real options to be considered within a world view that characterises the economic uncertainty. In the strategic long term planning framework, technical uncertainty is addressed through the planning process, investment centre estimate levels and cyclical optimisation based on exploitation of the remaining mineral resource (the exclusive mineral resource).

Note: Both economic and technical uncertainty change over time, and their effects on DCF valuation are addressed in the project value tracking (PVT) logic articulated in Section 11.10.

Financial option tools - challenges

There are a number of technical difficulties in broadly applying standard financial option valuation tools like Black-Scholes-Merton to real options; one of the key challenges being to establish a figure for volatility for which there is often no historical data (Samis *et al*, 2003).

To determine a project's volatility a financial model must be developed using the most likely values for all factors that drive revenue and cost. These are then used to calculate the expected total costs and revenues for the DCF component of value. Then for each factor it is necessary to develop a range of possible values. These ranges are used in a stochastic simulation to extract the mean and standard deviation of revenues, costs and profits. The standard deviations are then used in the calculation of an adjusted volatility which is used in the option valuation. This process is fraught with challenges in that, if the original estimates are incorrect (due to inherent uncertainty) and / or the discount rate is wrong then the volatility is incorrect and the process is flawed.

Pragmatically the more uncertain a project is the higher the probability that the option analysis, regardless of method, is incorrect. What is more relevant is establishing relative value of projects within a portfolio, under a given set of assumptions regarding a future world view / scenario. This then allows efforts to be focused, and results in the progressive selection and inclusion into the business plan of better projects (value optimisation). This reduces overall portfolio risk and results in refinement of the mineral asset portfolio.

Total value; option and DCF value in the SLTP framework

Real options and discounted cash flow valuation methods are not mutually exclusive but complementary. The DCF valuation provides a base estimate of value under an assumed risk adjusted discount rate that accounts for negative uncertainty whilst the option valuation can add the impact of positive uncertainty. Accepting the concept that a project value has both a DCF and option component it is evident that the contribution of each component will vary according to the uncertainty. In the early stages of project development the value of the DCF component will be relatively low because of the need to have a high discount rate to adjust for the uncertain nature of future cash flows whilst the option component will be high owing to the same uncertainty. This is represented schematically in Figure 11.9.5.

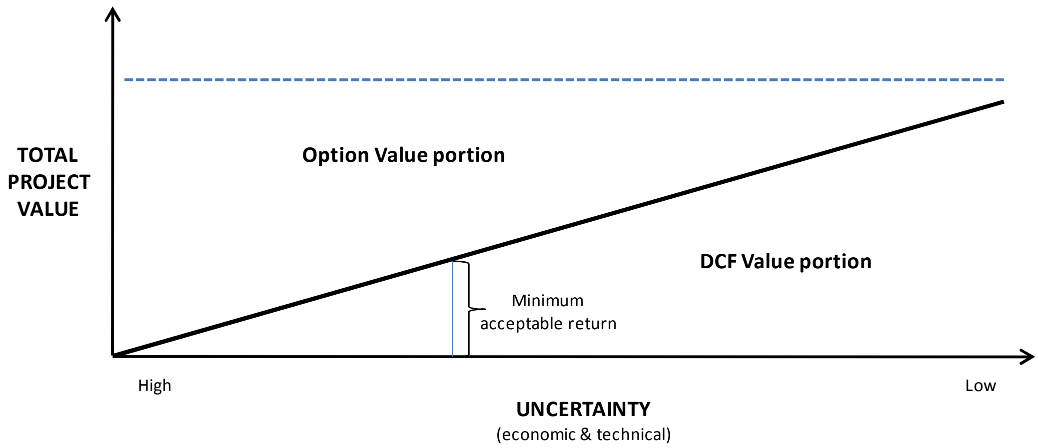


Figure 11.9.5 Schematic – components of total project value – DCF and real option

The caveat is however that all potential investments included in a project portfolio should have an acceptable minimum rate of return based on the worst case economic uncertainty encompassed in the prevailing downside world view / scenario, viz. they should still have a reasonable prospect of providing a return in excess of the initial cost of capital for a given worst case world view / scenario.

The easy inclusion / exclusion decisions lie around projects that have a high total value largely made up of a DCF valuation and those with low total value, that are well below a minimum acceptable DCF return and have little option value. However the challenge lies with projects that have a high option value, with a DCF valuation marginally below an acceptable minimum return.

The structure and process of the strategic long term planning framework provides for this in that these projects are not included in the business plan profile (i.e. they will fall into the NIB – (eng) and NIB – (nw) investment centre categories) and are reassessed on an annual basis (or following an unexpected, material shift in market or technology conditions) until they earn a right of way under a forecast world view / scenario.

The concept of real options and inclusion into long term planning processes has, in the past, been clouded by attempting to utilise financial instruments designed for markets in mineral resource investment decision making. People generally understand the concept of a real option as it is used for many daily decisions. However the challenge has been to integrate it into routine mine planning decision making.

11.9.6 Enterprise / portfolio value optimisation

Business strategy defines the context in which the mineral assets are to be exploited. Strategic objectives relating to market capacity (the ability to absorb output, ultimately leading to market share), operating cost curve positioning and targeted return on investment (leading to capital availability), coupled with the nature of the mineral assets in the portfolio, shape the potential overall exploitation trajectory.

For a multi, mineral asset holding organisation, i.e. one with multiple possible sources of metal production, it is highly unlikely that the business strategy will allow unbridled expansion. Typically this constraint manifests as capital availability (based on sustainable growth and necessary return on capital) and the inability of the market to absorb increased production volumes without significant reductions in metal prices. Within this context the business plan portfolio, thus comprises those investment centres which meet a value maximisation objective within the strategic constraints.

Typically the business plan would thus comprise a collation of investment centres that:

- Generate a production profile that provides metal to market at a rate that matches the most likely macro-economic world view (scenario);
- Give an acceptable return on investment (meet a prescribed hurdle rate) for a defined balance sheet structure (debt levels); and
- Ensure security of mineral right tenure through progressive utilisation of mining rights ("use it or lose it").

Within this framework individual projects (expansion or replacement) will compete for funding based on criteria of:

- Return on investment;
- Timing of metal to market;
- Future operating cost positioning relative to the competitors; and
- Sequencing or ability to unlock future higher value options.

Critical to this overall approach is understanding where the greatest opportunity and flexibility exists, within the value chain, to optimise overall business value. This concept is represented in Figure 11.9.6 which represents the value chain for an integrated PGM producer. As metal moves from mining operations to refined metal, fewer options exist to significantly influence the value of production.

Multiple potential sources of production exist at mining right level. This choice is created by having options as to which reef(s) to exploit, from where (geozones) in the mineral asset portfolio. On this basis it is possible to flex PGM product mix (e.g. Pt to Pd ratio) to meet anticipated market demand, operating cost profile and mining capital investment requirement.

At the concentrating stage opportunity exists to process ore separately by reef type or in mixed feed concentrators; with each option having specific characteristics in terms of recovery efficiency, and operating and capital cost effectiveness. However the extent of the choice is inevitably reduced as, typically, multiple mining production sources are usually fed to single concentrators to achieve scale benefits and to minimise environmental permitting requirements.

Further flexibility may exist, at the smelting stage, if multiple furnaces with differing operational characteristics (recovery efficiency and operating cost) and positional efficiencies (concentrate transport costs) exist. However this flexibility, and that of the further elements of base metal and precious metal recovery stages, is limited.

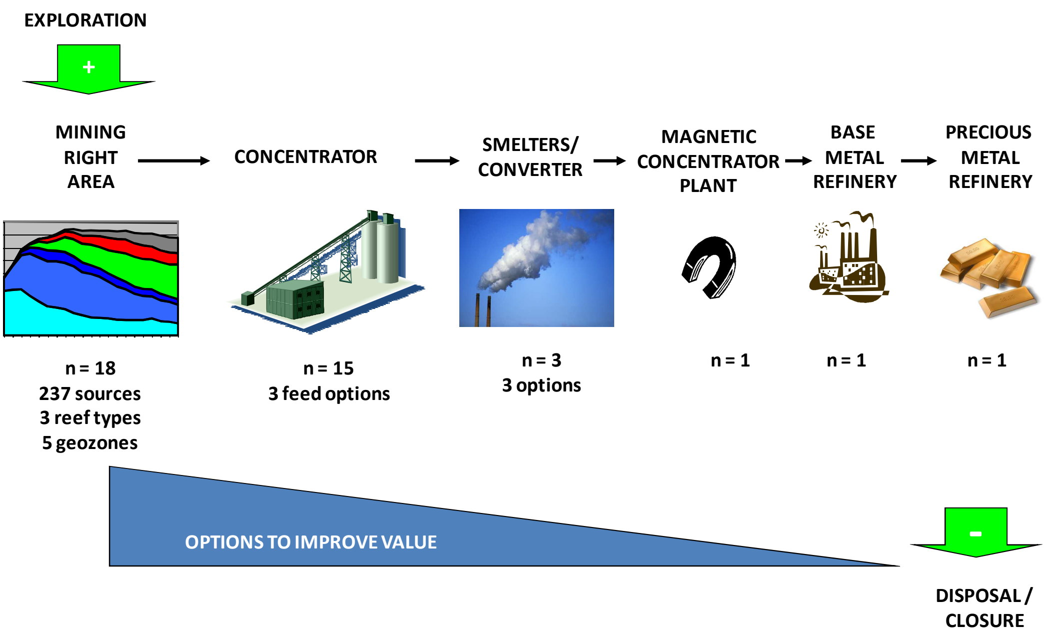


Figure 11.9.6 Typical integrated PGM producer value chain (n = number of units)

Enterprise optimisation

Optimisation techniques can be used to enhance the value of the business by maximising value associated with the flow of metal through the different elements of the value chain. The key challenge is to simultaneously optimise elements of the value chain rather than to optimise component parts in isolation from the remainder of the elements.

Enterprise optimisation is therefore based on building an integrated geological, mining, processing and market model which allows optimisation of variables along the value chain. This allows development of strategic long term plans that are optimised on a value chain basis using mineral asset portfolios coupled with existing and planned infrastructure (mining, process and transportation).

PGM production from multiple mineral assets is particularly suited to enterprise optimisation logic because of multiple reef sources, variable mining methods (open pit, mechanised, conventional, hybrid), variable PGM and base metal mineralogy, variable concentrating options, smelting and refining capacities across multiple units and differing power and transport requirements.

Enterprise optimisation is thus the process whereby all the elements of the value chain are examined and optimised simultaneously, to allow decisions on:

- Mining schedules – where and at what rate to mine (pit and/or underground);
- Cut-off grade and blending – what to discard, stockpile or process;
- Processing path and/or plant operating strategy;
- Processing capacity requirements;
- Logistics configuration;
- Capital sizing of all steps in the value chain; and
- Product specification, mix and timing.

The result is a long term plan with significantly improved cash flow profile, reducing risk and creating value options that can be varied according to the anticipated scenario / world view. Additional opportunities thus exist to model potential future scenarios and identify how to capitalise on potential opportunities and / or mitigate threats. Development of in house enterprise or group value optimisation tools / expertise, or the contracting out of this work to external entities is an integral part of value based management.

Project ranking and prioritisation logic

Despite categorising projects that form the mine extraction strategy and mining right plan on the basis of engineering confidence of estimate (levels 2a, 2b, 2c and 3), it is still necessary to prioritise projects on the basis of value add to the overall business plan.

The primary measure of value, in the overall strategic long term planning process is that of net present value (NPV) coupled with internal rate of return (IRR) relative to an agreed minimum rate of return (an investment hurdle rate, either weighted average cost of capital or a risk adjusted discount rate). This is done on an incremental basis for each project.

However given that the business plan is a combination of a short term budget period plus a long term plan it is necessary to bring into consideration the effect of short term cash flow. The long term objective of the organisation is to maximise value but this has to be tempered with the need for balance sheet management and near term cash flows.

However, owing to the sequential nature of mining as depth increases across a strike constrained mining right area, an additional element of spatial location and project dependency on prior extraction of an up-dip investment centre (IC) must be acknowledged, i.e. the value of investment centre D may be contingent on extraction of a prior up-dip block of ground contained in investment centre C. Dependency of projects must be acknowledged, if it is relevant, when prioritising investment centres.

On this basis investment centres (at level 1, 1e, 2a, 2b, 2c and 3) in the strategic long term planning production profile are ranked on three criteria in combination (Table 11.9.2):

- Net present value at the agreed discount rate (NPV) over the life of the IC / project;
- Operating profit (OP), viz. revenue minus working cost, over the three year budget period as a measure of contribution to near term cash flow before capital and taxation; and
- Net cash flow after tax (CF), over the three year budget period, as a measure of contribution after taxation and capital expenditure offsets.

Table 11.9.2 Investment centre prioritisation based on NPV and budget period cash flow

CAT.	$NPV_{(\%)}$ (life)	Operating Profit (3 yr budget)	Cash Flow (3 yr budget)	Comment
A	+ve	+ve	+ve	Rank on NPV
B	+ve	+ve	-ve	High impact projects
C	+ve	-ve	-ve	Longer lead time to production
	-ve	+ve	+ve	Future capex required (>3yr)
D	-ve	+ve	-ve	Future capex required (>3yr)
E	-ve	-ve	-ve	Re-assess & re-engineer

The relationship of this prioritisation relative to production can be represented visually as per Figure 11.9.7. This process allows rapid assessment of what proportion of planned output is associated with which ranking category, relative to any production constraint, facilitating further action. This profile can be constructed for any world view or scenario and any fall-back positions defined by contingency planning.

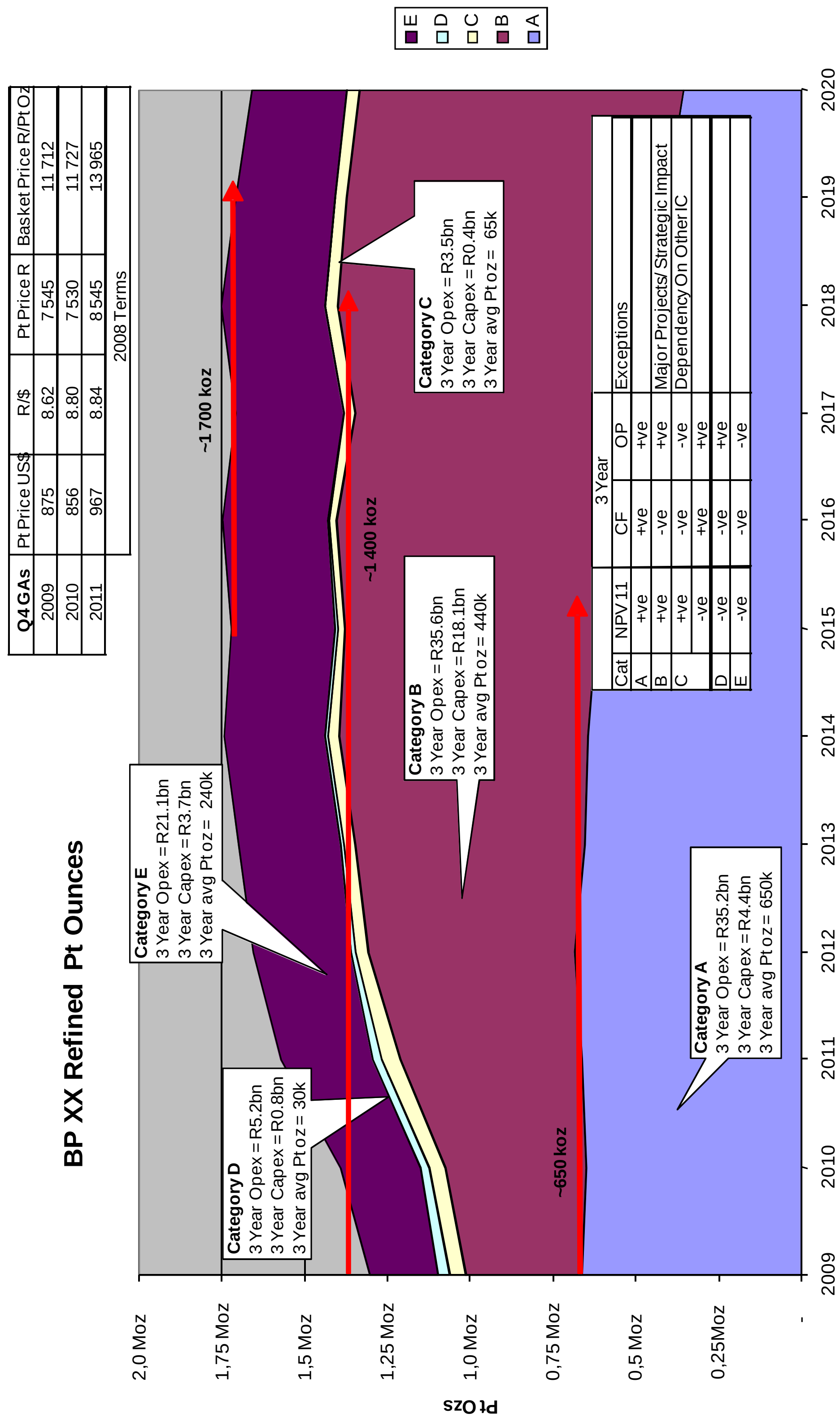


Figure 11.9.7 Diagrammatic relationship between production level and investment centre prioritisation

11.9.7 Contribution to the Conceptual Framework

The objective of this section is to clarify and define the preferred approach to valuation modelling of capital investment decisions and provide a basis for consistent valuation modelling practice in the strategic long term planning process. Critical elements and contributions are:

- Discounted cash flow (DCF) methodology is applied with emphasis on net present value (NPV) and internal rate of return (IRR).
- Distinction is made between the *capital investment decision* in which consideration of historic / sunk cash flows is excluded, as it has no bearing on the future viability of the investment, and assessment of overall *business performance* where it is necessary to include all prior cash flows. viz. the business performance evaluation should include all sunk or historic cash flows (including revenues and spent capital expenditure and costs).
- Determination of project value (NPV) is based on the philosophy of a differential value obtained from the difference between the base plan (level 1 plan i.e. the agreed and financed production, cost and capital profile associated with all investment centres at level 1e and 1 with an economic tail management applied) and the level 1 plan plus the project (with its associated combined production, cost and capital profile plus economic tail management) i.e. mine plus project less mine without project.
- Valuations are conducted with and without tax shield benefits. Excluding tax shield benefits (stand alone assessment) allows ranking of projects whilst inclusion of tax shield benefits indicates the likely return from the project once included into the overall business plan portfolio.
- Real option valuation logic is included into the strategic long term planning process through:
    - Defining world views / scenarios to allow numbers to be associated with uncertainty (economic uncertainty);
    - Investment centre categorisation by confidence of estimate (technical uncertainty);
    - Defining minimum DCF investment criteria (e.g. cost of capital and risk adjusted discount rates) to allow inclusion in the plan;
    - Having a defined contingency plan that highlights the relative priority of options (maintain, expand, close, dispose) available for consideration;
    - Cyclically evaluating all options within a mining right area (the mine extraction strategy) with the intention of the best option, that meets a strategic intent (the business plan constraints) being selected; and

- o Continuous transparency within the mining right plan portfolio of investment centres.

- Enterprise optimisation provides an opportunity to further enhance value generation and real option assessment. Techniques and tools are available (via external consultants) for open pit operations. An internal prototype narrow tabular model using genetic algorithms has been developed and is currently under trial.

- Project ranking and prioritisation methodology can be relatively simplistic and based on NPV, short term cash flow and inter-investment centre (spatial) dependencies after any strategic consideration (e.g. mineral right tenure requirements).

11.10 Project value tracking (PVT)

This work was first published by Pearson-Taylor and Smith in 2006 at the Second International Seminar on Strategic versus Tactical Approaches in Mining, in Perth, Australia. Subsequent to this further refinements were made and the concept and tools referred to in different SAIMM publications (Smith *et al*, 2006a, Smith *et al,* 2006b, Smith *et al*, 2007).

11.10.1 Introduction

The implementation of a given strategic long term plan is subject to adjustment according to short term changes in market demand and general economic circumstances. The ability to effectively adjust to changing circumstances is a function of the nature / diversity of the mineral asset portfolio, in particular the number, variety and output capacity of existing production sites and potential projects available and information for decision making.

The systematic and periodic tracking of the business case value of an operation or a project is a critical tool in allowing continuous portfolio optimisation and managing capital allocation for the exploitation of mineral assets.

Project value tracking (PVT) analysis takes the form of a waterfall chart, which illustrates the relative importance of various external (environmental variables) and internal (management levers) factors that have caused the NPV to change since the original view baseline model. A typical waterfall chart output as generated in the analysis is indicated in Figure 11.10.1.

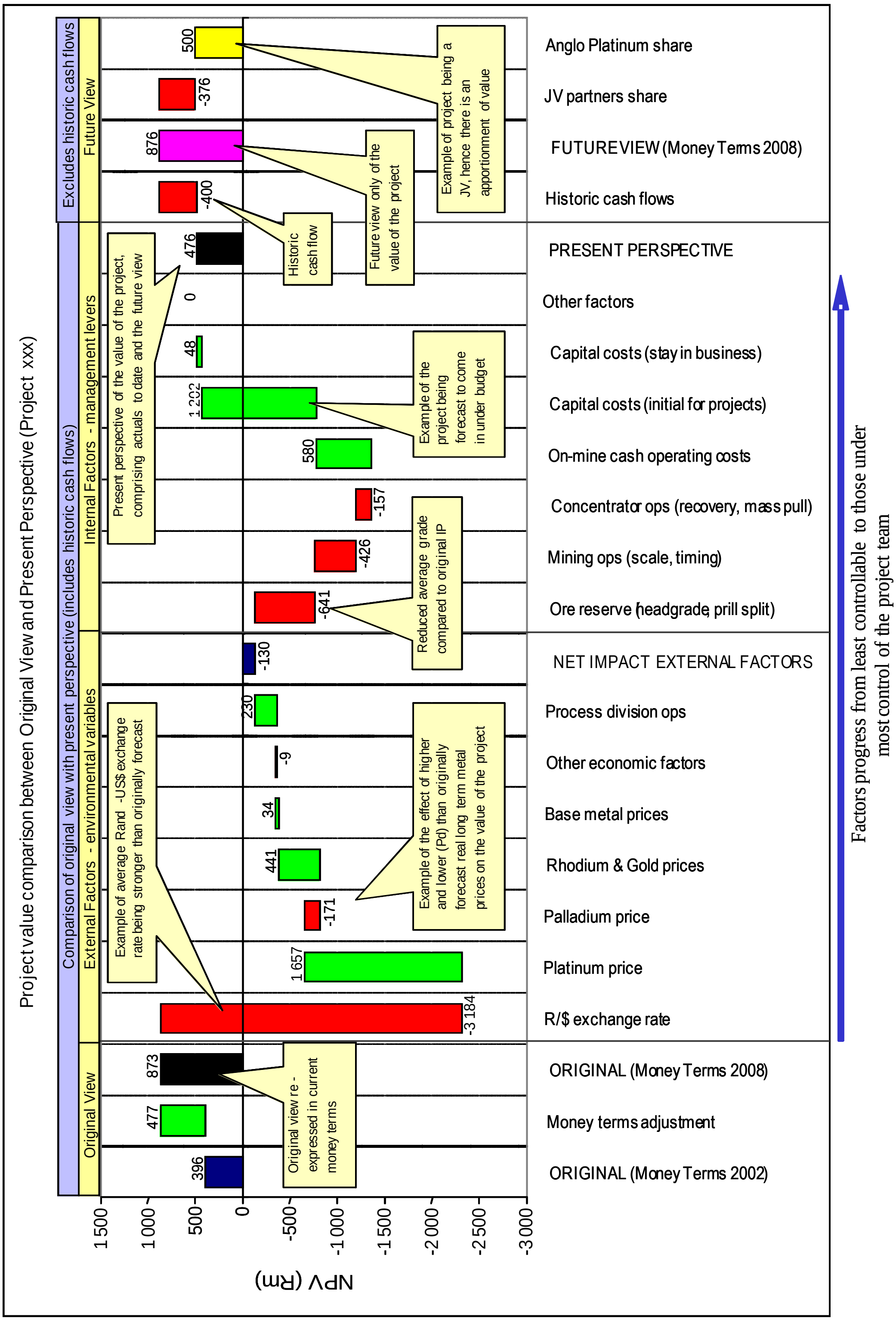


Figure 11.10.1 Project Value Tracking (PVT) – typical waterfall chart output

Conducting modelling on an incremental stand-alone basis, a project once approved has associated with it, an original view of how that investment proposal of the project is expected to perform over time. At regular intervals it is therefore possible to compare the present perspective of the project against this original view over the same timeline. The term present perspective refers to what has occurred up to the present time and the view of the future at that time.

11.10.2 Project value tracking – the HSF solution

Traditional waterfall charts are spreadsheet based, however with the increased size of project portfolio associated with a large mineral asset base it is necessary to move to a system that can handle larger data volume and provides an effective audit trail and consolidation function. On this basis the PVT logic has been converted into an HSF application which utilises existing investment centres and other LTP data sources.

The objectives of being able to compile a waterfall chart in HSF were:

- To produce an incremental variance (or waterfall) NPV analysis between the two points (illustrated as black bars in Figure 11.10.1) of the present perspective of a project and the original view over the same project life timeline;
- To utilise existing Anglo Platinum HSF template models in a seamless and easy-to-use system that produces a waterfall chart analysis automatically; and
- To replace a manual process of incrementally moving groups of data from one model to the other and documenting the NPV change and then displaying this information in an external EXCEL waterfall chart.

<u>Waterfall chart methodology using HSF</u>

The waterfall chart solution uses existing HSF model templates and is schematically illustrated in Figure 11.10.2.

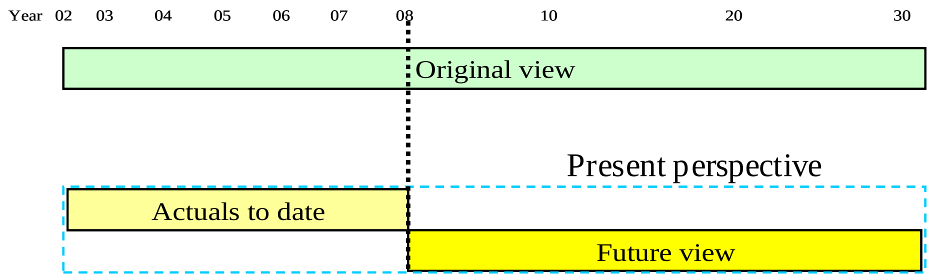


Figure 11.10.2 PVT – HSF model methodology

The waterfall chart comparison is conducted as follows:
A comparison is made up of three underlying HSF IC models:

- The original view of the project model;
- The actuals to date for the project model; and
- The future view of the project model.

The money terms of the underlying models are as follows:

- The original view model is in original real money terms;
- The actuals to date model is in nominal money terms; and
- The future view model is in current real money terms.

These models then have their data entered into two separate scenarios in the HSF waterfall model, which has been custom-made for the purpose.

Using the consolidator function in this model:

- The original view model data is entered into one scenario, named original view (green rectangular block) in Figure 11.10.2;
- The actuals to date, and the future view models are combined and entered into the other scenario, named present perspective (blue trapezoidal block) in Figure 11.10.2; and
- The present perspective data is restated back to the same money terms as the data of the original view model so that a comparison in the same money terms is possible. This is achieved by utilising a money terms converter sub-program within the waterfall.

The waterfall model then iterates the changes between the two scenarios in the steps outlined in Figure 11.10.3 using HSF's combined scenarios feature in original real money terms. This is done for each series of data in the present perspective that represents a factor/bar on the waterfall chart. Each is inserted one by one into the original view model overwriting the original forecast assumptions; with the model being calculated at each step to understand the effect on the NPV of the project.

The model then re-expresses the incremental NPVs for each step in current real money terms and produces a customised waterfall chart, where green bars highlight a positive impact on NPV and red bars illustrate a negative impact.

The waterfall chart therefore shows the effect of:

- The re-expression of the original view of the project into current real money terms;

- The iterated NPV steps to arrive at the present perspective of the project in current real money terms; and
- The effect of including and excluding historical cash flows on the value of the project, i.e. a comparison of project value between the present perspective and the future view, both in current real money terms.

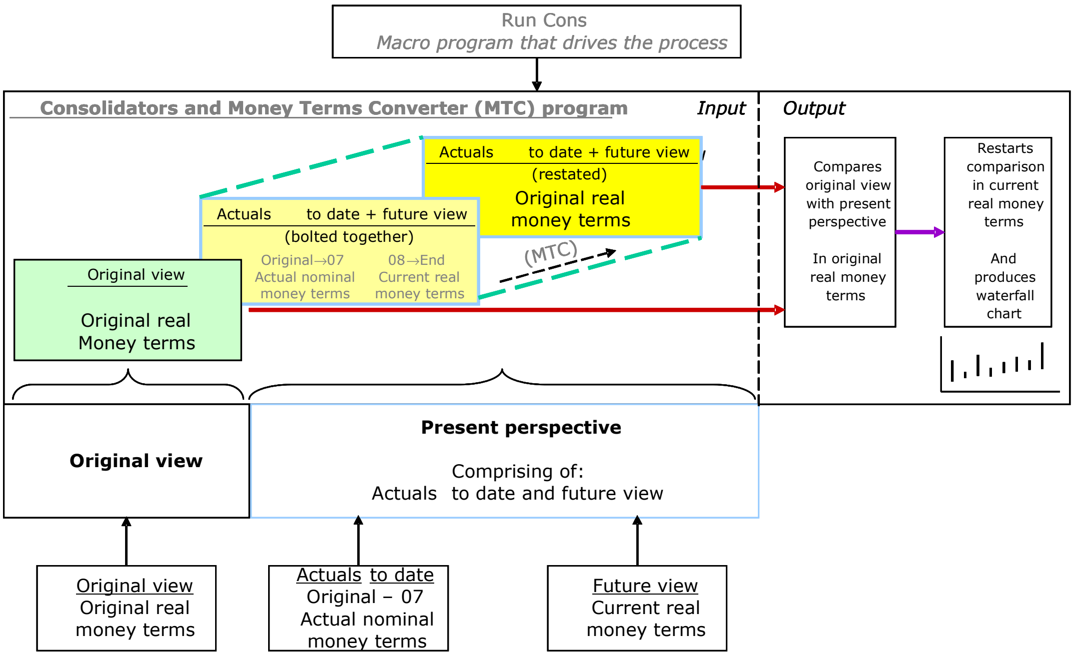


Figure 11.10.3 Schematic representation of the waterfall chart methodology in HSF

The general principal applied for presentation purposes is that original view baseline model NPV is adjusted and re-expressed in the same terms as the current money terms of the present perspective of the operation or project, i.e. in 2008, a project which was approved in 2002 would have its NPV re-expressed by the nominal weighted average cost of capital (WACC%) to 2008 money terms so that it could be compared to the present perspective of the project.

The baseline against which the NPV is tracked is:

- Operations - the last signed-off long term plan (LTP) over the operation's mining right area;
- Approved projects - the original investment proposal (IP) or latest signed-off change of scope; and
- Unapproved projects - the last signed-off stage-gate study work, feasibility (level 2a), pre-feasibility (level 2b), and conceptual (level 2c) used to obtain funding for the project.

Then adjustments are made, first to those factors beyond the control of the operation or project team (external factors – environmental variables), and then to those factors within the control of the team (internal factors – management levers). Within these broad divisions, the degree to which the factor can be influenced should decide the order in which the waterfall chart is constructed.

The ownership structure of the project (e.g. joint venture (JV) involvement) or any other value issue that needs emphasis is addressed as the final item on the waterfall chart. The order in which the changes are made at present within Anglo Platinum is summarised in Table 11.10.1 below:

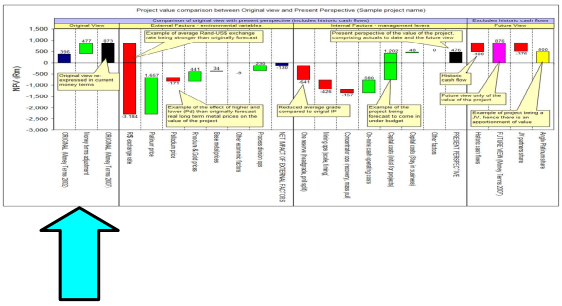
Table 11.10.1 Project value tracking analysis – description of waterfall chart components

Step	Description	Comment
Original view (in original money terms)		
0	Original investment proposal or latest change of scope	Original money terms & discount date
0	Money terms adjustment	Escalation by CPIX% and appropriate mid-year discount rate for the project to current money terms
0	Re-expressed investment proposal or latest change of scope	Current money terms & discount rate of present perspective of the model
Original view (in current money terms)		
Step	Description	Comment
External factors		
1	Rand-US dollar exchange rate	Rand-US$
2	Platinum price	Pt (US$/oz)
3	Palladium price	Pd (US$/oz)
4	Rhodium, other PGMs & gold prices	Rh, Ir, Ru & Au prices (US$/oz)
5	Base metal prices	Ni, Cu & Co prices (US$/lb)
6	Other economic factors	Royalties, working capital, commissions & discounts, taxation & capitalised interest effects, % sold of production, carbon emission cost effect

7	Process operations	Off-mine cash costs – smelting, BMR & PMR refining & transporting costs, process recoveries & pipelines, cost of third party concentrate purchase (if applicable)
Net impact of external factors only		
Step	Description	Comment
Internal factors		
8	Ore reserve	Headgrade & metal ratio split
9	Mining operation	Ore tons milled throughput & timing
10	Concentrator operation	Concentrator recoveries & mass pull
11	On-mine cash operating costs	On-mine cash costs – shafthead, concentrator & indirect, each broken up into labour, stores, contractors, utilities & sundries
12	Initial capital expenditure	Initial capex for major projects (if applicable)
13	Stay in business capex	Stay in business capex
14	Other factors	Any other changes not covered (if applicable)
Present perspective - net impact of all factors (in current money terms)		
Step	Description	Comment
Future view (in current money terms)		
15	Exclusion of historic cash flow	Removal of historic cash flow leaves current forward looking cash flow only
16	Future view	Aligns operation or project with LTP and reflects future view on a forward looking basis in current money terms
Other value issues		
17	Partner's share	JV impact on value to partner (if applicable)
17	Anglo Platinum share	JV impact on value to Anglo Platinum (if applicable)

Procedure for restating the original view baseline model (reference to Figure 11.10.1)

Original view baseline model

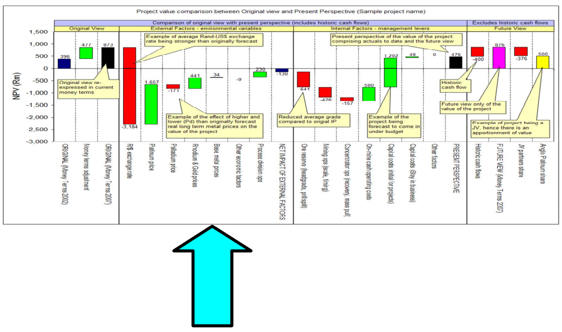


The original investment proposal (or other published document chosen as the baseline, such as a change of scope) will have its value expressed in the original money terms and discount date (year) that were applicable at the time of approval or sign-off. The initial step is to restate this model value in the same current money terms as the present perspective model. This is achieved by escalating the original view baseline model NPV by the nominal WACC% to reflect the change in the time value of the NPV, which is compounded annually and equivalent to:

$((\text{actual CPIX\%}) \times (\text{required company discount rate}))^{n}$ years

Current valuation models use varying discount rates depending on the type of operation or project. Once the original view baseline model has been re-expressed in the same current money terms and to the same discount rate as the present perspective model, the process of changing the external and internal factors by incremental steps can proceed [step 0].

External factors



Rand-US dollar exchange rate: The first GA to change is the Rand-US dollar exchange rate [step 1].

Platinum group metal (PGM) prices: Second, PGM prices are brought into line with current GAs. This should be done in three steps: individually for platinum, then palladium, then subsequently for rhodium, other PGMs (iridium and ruthenium) and gold [steps 2,3,4].

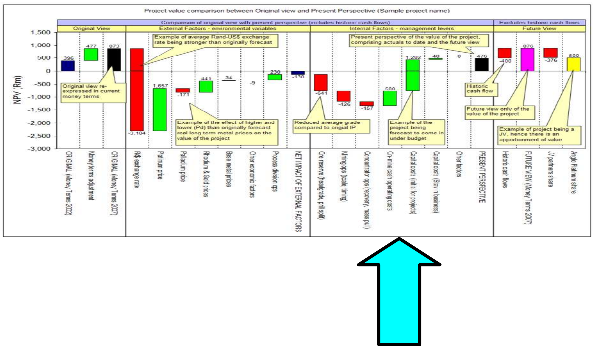
Base metal (BM) prices: BM prices (nickel, copper and cobalt) are dealt with in the same way, as a single step [step 5].

Other economic factors: Other economic factors are dealt with as one step. It comprises: royalties, changes in working capital, changes in commissions and discounts, taxation and capitalised interest effects, percentage of produced metal sold, and carbon emission cost effect [step 6].

Process division operations: Although not strictly an external factor, off-mine elements such as: smelting, base metal refinery (BMR) and precious metal refinery (PMR), and ore and concentrate transport costs, together with smelting and refinery recoveries and pipelines, cost of third party concentrate purchase (if applicable) are assumed to be largely beyond the control of the operational or project team. Therefore, they can usefully be illustrated at this point. All off-mine factors are changed as a single step [step 7].

Once this adjustment is complete, the waterfall model comparison should fully reflect present perspective GAs and off-mine elements. The NPV of the project at this stage therefore reflects the impact of all of the external factors.

Internal factors



Internal (management levers) specific factors are now considered, they are defined as the on-mine elements contained in the company's HSF modelling input sheets. The order of substitution of the factors would be as follows:

Ore reserve: This factor reflects any differences between PGM and BM head grades (quality of the ore reserve). Prill split changes should also be considered at this point due to PGMs poly-metallic nature [step 8].

Mining operation: The mining production (quantity produced from the ore reserve) step may be incorporated in two stages in order to identify any timing delay effects, and/or change of scale of operational output in terms of tonnage, for example, changes in a project from 250 kt per month in the original view model to the present perspective of 300 kt per month, with a two year delay to first production [step 9].

Concentrator operation: Any concentrator recovery and mass pull changes, noting that there might be differences between the PGMs and BMs, are then considered [step 10].

On-mine cash operating costs: On-mine cash operating costs, which are divided up into: shafthead, concentrator and central services (or indirect) costs are examined next [step 11].

Capital costs: Two types of capital expenditure are applied; initial capex for major projects and stay in business (or ongoing) capex, which is applicable to both existing operations and proposed major projects. See Figure 11.10.1.

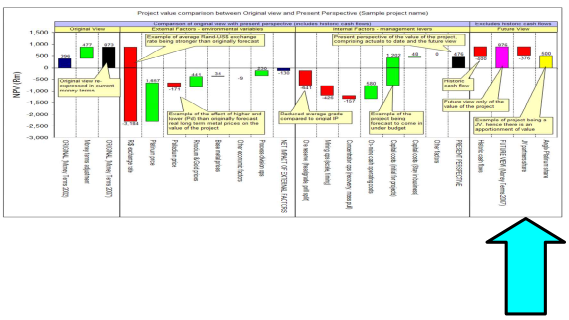
This section may therefore be made up of two steps:

- Initial capex will only be applicable if a major project (either approved or in a study phase) is being examined and compared. The two categories of major project are expansion or replacement. An existing (level 1) operation will not have any initial project capex associated with it [step 12].
- Stay in business capital will be applicable to both a major project (either approved or in a study phase) and an existing (level 1) operation. It is the capital expenditure required to maintain the life of existing assets without materially increasing capacity. The categories of stay in business capital expenditure are: replacement of specific equipment, business improvements, risk (safety, legislative, and business), ore reserve development and shared infrastructure (specific to area within an operation, operation wide and external to operations) [step 13].

Other factors: If in a particular instance a change has occurred that is not covered by any of the above categories, then it should be evaluated under the other factors category. An explanatory note should be included to describe the change [step 14].

Once this adjustment has been made the cumulative NPV result of all of these incremental steps gives the total NPV variance (either positively or negatively) from the original view baseline model to the present perspective model, both being in current real money terms and including all historical cash flows, enabling a valid business investment performance comparison against that of the original investment decision to be made.

Future view



Exclusion of historic cash flows: Eliminating historical cash flows, which include sunk capital expenditure, operating costs and any revenues derived from historical production, plus tax effects (if applicable), will leave only the current forward looking cash flow of the project [step 15].

Future view: After the historic cash flows have been excluded, the end point will now be aligned with the latest forward looking version in the group's LTP, and reflect the future view model's NPV of the operation or project [step 16].

Other value issues: One or more additional bars may be needed to illustrate the ownership structure of the project, e.g. if it is associated with a JV (partner's share and Anglo Platinum's share of value of the JV) or any other value issue that needs to be emphasised [step 17].

11.10.3 Contribution to the Conceptual Framework

The ability to develop a continuous feedback loop of business investment performance relative to original investment criteria (technical, capital and otherwise) is essential if investment decision making and value maximisation is to be continuously improved. Value tracking of capital investment decisions is thus critical for mineral asset value optimisation and capital prioritisation in large multi investment organisations.

Project value tracking should be incorporated into governance reporting cycles (typically quarterly) using existing systems and applications. This is achieved through the use of common HSF investment centre models, as developed and applied in the overall short and long term planning process. Valuation and tracking of projects is thus aligned with the overall business planning process.

11.11 Supporting capability

The ability of a mining company to effectively execute an integrated business plan is dependent on alignment of activities of all participants in the company value chain. One of the objectives of the strategic long term planning process is to create alignment of activities. This section highlights critical supporting capabilities to create an integrated aligned business plan.

11.11.1 Introduction

The business execution activities of an integrated PGM mining company can be broadly sub-divided along the value chain into two groupings – operating and support. The operating activities are mining and process, underpinned by project and engineering execution. These core operating activities are in turn provided support services by the functions of human resources, operational engineering, marketing, finance and corporate affairs. This is schematically represented in Figure 11.11.1.

As indicated in Chapter 7 (Platinum value chain), core optimisation of production in response to anticipated market and stakeholder demand occurs, for a multi mining right entity, within the mining activity. The related operating activities of process and projects are structured and optimised to match the anticipated strategic long term plan (SLTP) production profile. Process capacity is designed and implemented in anticipation of the aligned mining production profile developed in the SLTP. Projects necessary to the SLTP are then optimised, engineered and executed according to the SLTP timing requirements.

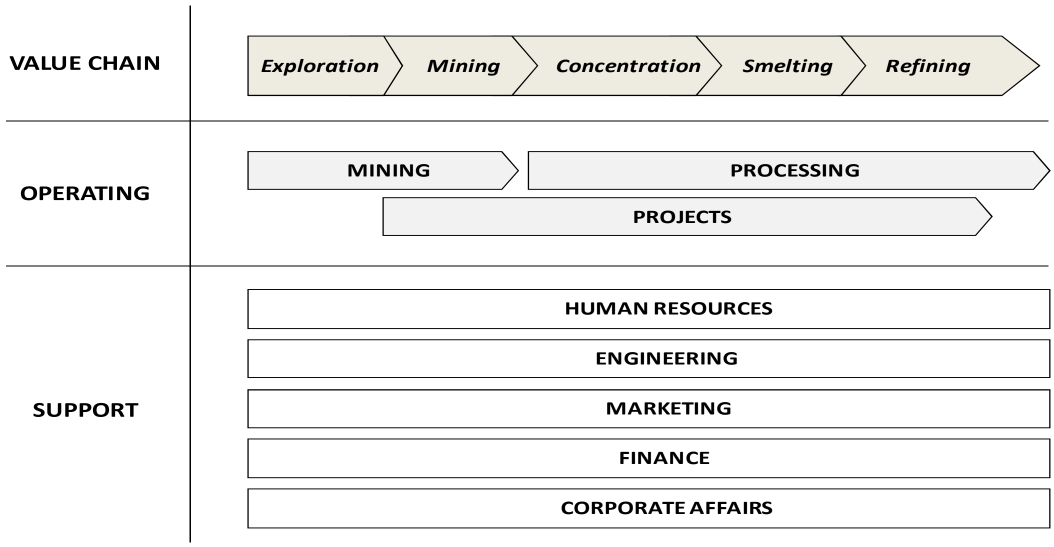


Figure 11.11.1 Alignment of operating and support activities to the value chain

Similarly the support functions of human resources, finance, engineering, marketing and corporate affairs create capacity and capability to allow effective execution of the SLTP.

11.11.2 Process

Alignment of the process value chain activity is primarily capacity driven. Consideration is given to installed capacity for each of the key process elements e.g. concentrators, smelters, converter, magnetic concentrate, base metal refinery and precious metal refinery. A typical capacity versus planned throughput chart is indicated in Figure 11.11.2.

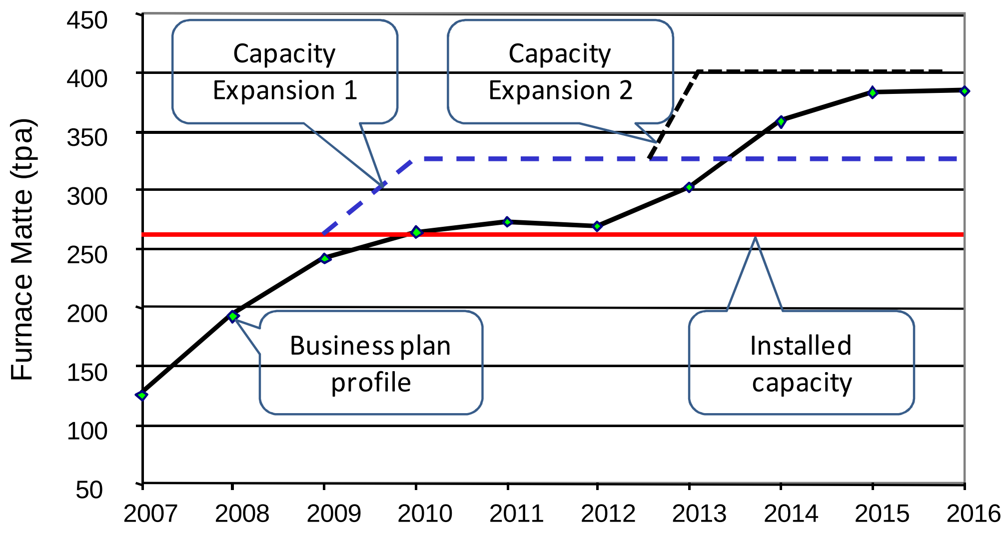


Figure 11.11.2 Typical capacity planning profile for process element

Based on this type of data, opportunities for scale and timing optimisation are explored to ensure timing and capital efficiency. Capacity decisions defined during this process then influence parameters applied in the global assumptions where relevant. Decisions on installed capacity associated with the final business plan then influence staffing structures, operating cost and capital (project and SIB) requirements.

11.11.3 Projects

The project portfolio for the company is defined by the project content of the business plan. Each mineral asset has, by virtue of its long term plan, a sequence of projects which require execution, on a timeline, to deliver on the plan. The aggregated project requirements across the company provide the projects portfolio.

Necessary capacity, capability and infrastructure can then be created to execute the project portfolio as per the business plan timelines. Opportunities may exist to smooth capacity requirements through outsourcing dependent on the overall business model applied. Staffing and operating cost is determined by the capacity required to execute the project portfolio whilst overall project capital is defined by the project portfolio in the business plan.

11.11.4 Engineering and infrastructure

Engineering activities are primarily focused on *maintenance of the existing asset base* and *establishment of necessary infrastructure* to match SLTP requirements.

<u>Maintenance of the existing asset base</u>

These are the routine engineering activities required to maintain existing infrastructure.

<u>Establishment of SLTP aligned infrastructure</u>

Critical infrastructure in the areas of *electricity* supply and distribution, *water* supply and distribution, and *transportation* systems is necessary to allow execution of the SLTP. This infrastructure has long lead times and requires engagement with governmental structures and communities for approval and execution.

Electricity supply requirements are estimated from the business plan profiles based on project requirements plus anticipated process power draws. An interactive long term consumption estimation model should be constructed to forecast average power and peak power requirements based on production profiles. An integrated power supply and distribution strategy can then be developed that integrates anticipated Eskom power supply profiles with anticipated energy savings, self generation requirements and any shortfalls to be supplied from independent power producers.

Water is fundamental to the business of mining. Development of a SLTP aligned strategy for the use and discharge of water that caters for various medium and long term scenarios / world views is therefore critical. A water strategy plan that considers existing supply, potential storage facilities and inter-basin water movement should be developed. This plan should indicate anticipated shortfalls / excesses in supply at various stages in the business plan and contingency plans for alternate supplies, e.g. use of municipal grey water. Maintaining a close relationship with Government in the development of the medium to long-term water strategies to avoid competition for water resources is crucial. The overall water strategy should be fully integrated with provincial and municipal development plans.

Key principles are to:

- Manage water consumption to as low a level as possible;
- Guarantee water availability;
- Limit negative impacts on water sources; and
- Ensure that mining related consumption does not adversely impact the availability of water to other users.

The concept of the true value of water that takes into account the other costs of using water, such as social and ecosystem implications is central to this approach.

Similarly an integrated **transportation i**nfrastructure plan that aligns with the SLTP is necessary. Maintaining a close relationship with Government in the development and integration of the medium to long-term transportation strategies is crucial as substantial portions of transport infrastructure can be dual use and are often in public space.

Typically the transportation plan would encompass elements of:

- Ore transportation from mines to concentrator facilities (road / rail);
- Concentrate movement between concentrators and centralised smelter facilities (road / rail / pipeline);
- People movement to and from operations – usually road; and
- PGM precious metal transportation from refinery to airport.

Similar principles, to those applied to water, are utilised for transportation to minimise negative public impact.

11.11.5 Human resources

Outside of basic human resource strategy encompassing employee relations, industrial relations, HR skills and competencies, culture and values, the core consideration that is driven by the business plan is that of alignment of capacity and capability. Specific attention should be given to:

- Overall staffing levels and required skills by activity by operation;
- Longer term skills development;
- Housing requirements;
- Training requirements;
- Transformation; and
- Incentive schemes.

These aligned requirements then define the necessary operating cost structures and capital requirements to effectively execute the business plan.

11.11.6 Corporate affairs

Corporate affairs largely manifests in the realm of sustainable development. The Mineral and Petroleum Resources Development Act (MPRDA), under which mines are governed, fully embraces the concept of sustainable development in Section 37, which refers to the National Environmental Management Act’s definition of sustainable development as “the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations".

The MPRDA requires all mining operations to have social and labour plans and environmental management programmes in place, and to comply with, and publicly report on, progress towards meeting the requirements of the Mining Charter. The strategic long term plan provides the basis on which social and labour plans and environmental management programmes are structured to ensure alignment with overall business objectives.

11.11.7 Marketing

The interaction between the SLTP and marketing comprises two phases; the supply / demand dynamic and forecast market excesses / shortfalls that provide the initial input into the business strategic intent, and the alignment of sales contracts, by metal, based on the business plan that arises from the SLTP.

Industry and competitor analysis

An annual industry and competitor analysis is necessary to fully understand the market dynamic and likely supply / demand / pricing scenarios. These inputs are integral to the value based management approach (Section 11.6) and definition of metal pricing in the world view or scenario development that defines the global assumptions (Section 11.5).

Sales contracts

PGMs are primarily sold through contractual agreements with the primary consumers or fabricators (Section 7.4), with limited metal volumes moving through the open markets. The structure of these contracts (volume, price, delivery, form) is influenced by the forecast availability of metal arising from the business plan as developed through the SLTP.

11.11.8 Finance

Outside of the routine management accounting and corporate finance functions, finance activities are fundamentally focused on cash flow and balance sheet management for the SLTP. Mining projects are invariably long lead time, high capital requirement entities requiring cash flow management over extended periods. The ability to generate pro forma annual financial statements from the HSF models of the business plan arising from the SLTP, over a range of time periods for a range of scenarios, facilitates cash flow and balance sheet management.

11.11.9 Contribution to the Conceptual Framework

The ability of a mining company to effectively execute an integrated business plan is dependent on alignment of activities of all participants in the company value chain. One of the key objectives of the strategic long term planning framework is to create alignment of activities across functional groupings and along the company value chain.

The long term plan thus provides the basis for resource planning of all support capabilities (process, engineering, projects, infrastructure, human resources, finance, marketing, and corporate affairs). Supporting capability plans are aligned with the business plan requirements and resourced to ensure timely delivery of capacity and capability as necessary.

12 CONCLUDING CHAPTER

12.1 The Challenge

The challenge facing a mining company in South Africa, with multiple mining rights to PGM mineral resources of differing characteristics is to how to create sustainable value whilst operating within mandated strategic bounds, identified constraints, and variable market and economic conditions.

This challenge translates into the research question that this work addresses:

How does a company with rights to exploit multiple platinum group metal mineral resources of differing characteristics (e.g. location, grade, metal factor, exploitation method, metallurgical characteristics, physical location, socio-economic setting), select and implement a strategically aligned project portfolio that enables optimal mineral resource exploitation whilst operating within mandated strategic bounds, identified constraints, and variable market and economic conditions?

For a mining company to create sustainable value from mineral assets, it is necessary to:

- Optimise the composition of the mineral asset portfolio to align with strategic and business objectives;
- Create and operate long term assets within an anticipated long term business environment; and
- Create and retain flexibility of short term tactical response that allows effective response to short term shifts in the business environment.

To achieve this, it is necessary to:

- Allow the fixed physical nature of the mineral asset(s) to drive definition of the optimal (lowest capital cost, lowest operating cost, highest efficiency, maximised cash flow) technical solution to mining and concentrating activities;
- Define and apply different business environment perspectives, world views or scenarios, to determine possible economic viability under the different perspectives, i.e. define the value proposition under different scenarios – what are the options?
- Develop and resource a portfolio of production entities from the mineral asset portfolio that creates flexibility to near and longer term business environment

shifts, i.e. a production mix that allows variation of output (metals, operating cost, capital intensity) to respond to market demand and pricing.

These activities require a structured, integrated approach across all elements of the business value chain from exploration through to product sales. Typically, however, organisational structures and operating philosophies create discipline specific groupings (“silos”) across the organisation which work against alignment of purpose and integrated outcomes in the long term planning and exploitation of mineral assets.

The solution lies in systematic application of a series of tools and techniques, within a conceptual framework or philosophy, that aligns decisions and actions across the company, using a common language, standards, systems and processes, and defines the concept of *strategic long term planning* - the definition of which is the intent of this work.

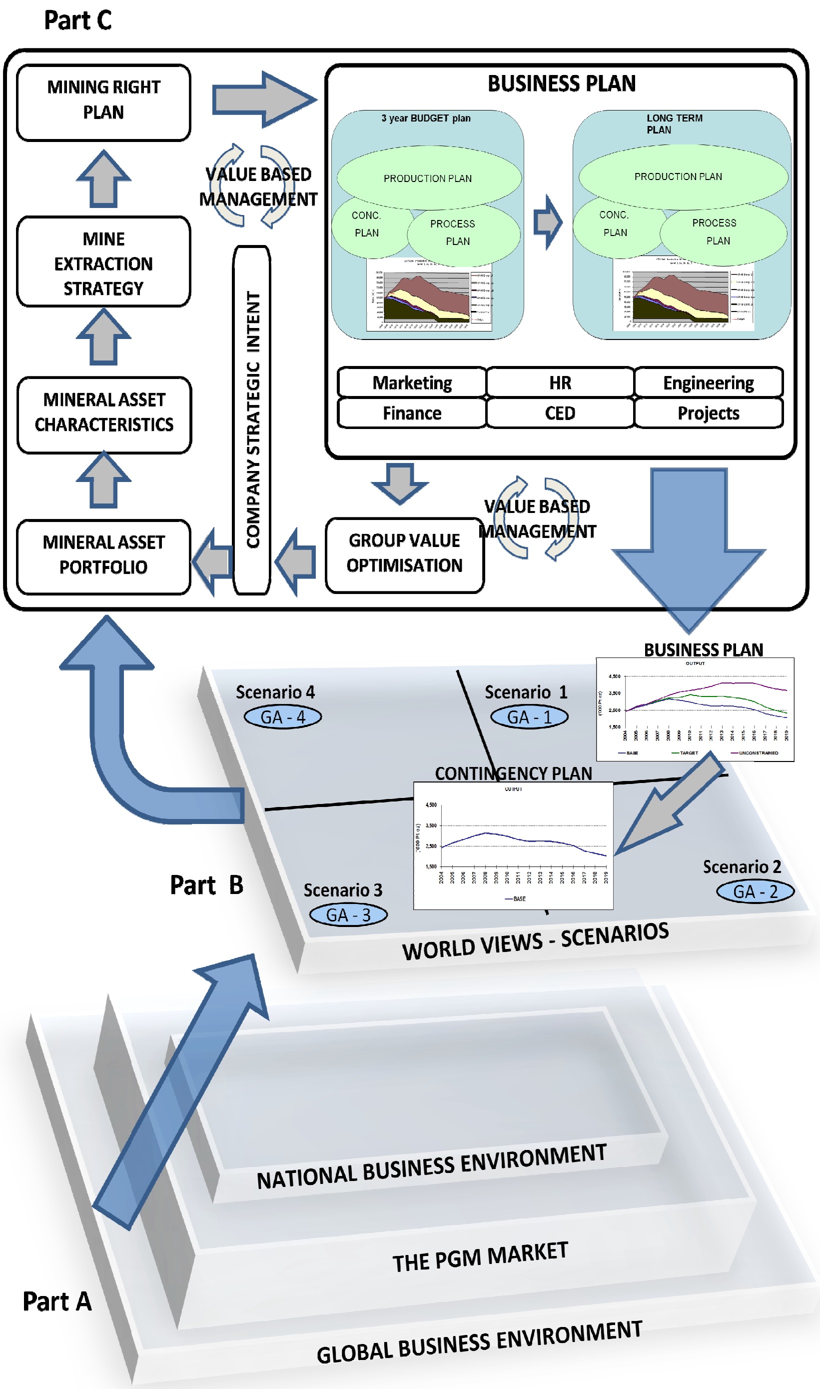
12.2 The conceptual framework

The inter relationship and nature of the strategic long term planning framework that enables this process is schematically represented in Figure 3.1,(repeated overleaf) should be read from the bottom of the diagram, as follows:

- The global and national business environments, in conjunction with the characteristics of the market for platinum group metals create the context in which world views or scenarios are developed. This is part A of the diagram.

- World views or scenarios (part B of the diagram) are constructed and used to develop long term planning parameters called global assumptions or GAs that represent the relevant underlying assumptions for each scenario, e.g. metal prices, exchange rates, escalation, etc. These planning parameters inform the financial analysis and optimisation of the business plan, and create the link between mineral asset portfolio utilisation and the market.

- The annual cyclical business planning process, as represented in part C of the diagram, is then executed using the planning parameters or GAs associated with the preferred or most likely scenario. The composition of the mineral asset portfolio is reviewed relative to the most likely scenario, the current state of execution of projects and company strategic intent. The physical characteristics of the individual mineral assets within the portfolio determine the development of a mine extraction strategy, the mining right plan, the budget and long term plan per asset and collectively for a multi-asset business. Concurrently value is optimised through application of value based management principles during the development of the strategic long term plan – at mineral asset level and company level for a multi-asset organisation.



- The business plan, which is the output of the strategic long term planning process, is then reassessed for a possible shift to the next most likely world view. Real options arising from evolving alternate trajectories are evaluated and a contingency plan is developed, based on planning parameters associated with the alternate scenario. This is the link from part C of the diagram back to part B.

  The business plan then forms the basis upon which the organisation is structured and resourced. Supporting, aligned execution plans are developed for the necessary supporting activities in finance, human resources, projects, engineering and infrastructure, and sustainable development. All of which takes place in an annual planning cycle.

12.3 The operating context

The global and national business environments, in conjunction with the characteristics of the market for platinum group metals (part A of the diagram) create the context in which a PGM company operates.

Key elements of this context are:

- Characteristics of the PGM mineral resource;
- Platinum value chain;
- Characteristics of the PGM market;
- Global business environment; and
- National business environment.

Each of these contextual elements contributes to, and influences, the world views or scenarios that create the context in which business planning takes place.

The PGM mineral resource

The ability to respond to variable PGM demand over long periods and create strategic planning flexibility, is dependent on being able to source production of PGMs from mineral assets with different metal ratio characteristics. Variability of metal content by geographical region is thus a strategic planning element that allows production portfolio development and creates flexibility to meet varying PGM demand over time.

Similarly, reef mix (UG2, Merensky, Platreef, MSZ) will impact saleable metal ratios and cost of production. The cost of production, in the Bushveld Complex, despite normal increases with depth and distance from infrastructure, has step change at ~750m below surface owing to the need to introduce refrigeration and cooling.

Holding mineral assets outside of the Bushveld Complex, creates longer term strategic flexibility, owing to the marked differences in Pt/Pd ratios, and will be beneficial in reducing overall long term mineral asset portfolio risk.

The platinum value chain

The PGM value chain is highly concentrated with five integrated suppliers (mining companies) providing most of the global supply of refined PGMs to a limited number of key intermediaries who service a broad spectrum of end users. Significant interdependency exists between industry participants, with the security of supply key for sustainable industry development.

The major industry producers tend to be integrated along the value chain and as such have considerable assets in the mining and processing value chain elements. This is a barrier to entry to new participants.

Owing to the nature of the mineral resource, underground mining of hard rock, narrow tabular, deposits predominates. This drives high capital intensity for access infrastructure development and long lead times to production.

Within the value chain the greatest opportunity to vary production of metals and the metal mix lies in the mining activity, owing to the greater number of sources of metal.

The bulk (~70%) of operating profit arises from mining and processing activities rather than from application and retail.

The understanding of the value chain and the relative contribution of each element and the participants is an integral part of value based management, the principle of which underpins value optimisation in the strategic long term planning framework .

The PGM market

The PGM industry is market driven and understanding the nature of demand is crucial to success. The demand for PGMs can be broadly characterised into two groupings; derived demand and created demand, the combination of which creates flexibility and sustains price over periods of economic volatility.

Current PGM industry revenues are concentrated in two end-use segments: automotive emission control and jewellery. The automotive segment accounts for about 60% of current market revenues and jewellery about 10%. Jewellery, as derived demand, acts as a counter-cyclical shock absorber when the supply/demand balance shifts.

The industrial demand segment demonstrates the versatility of PGMs and has achieved high growth rates from a low base. Fuel cells and emission control in the stationary fossil-fuel burning sector are potentially large opportunities for PGMs that are, as yet, unrealised.

Aspects that are likely to negatively impact PGM demand growth in the near and medium-term are:

- Record PGM price levels have increased thrifting (catalyst loading reduction) efforts and substitution of platinum by palladium in automotive segment, as well as slowed down PGM jewellery market penetration.
- Growth in recycling is accelerating due to current high PGM prices.
- Record fuel prices are driving shift to more fuel efficient vehicles including smaller and/or hybrid vehicles which (depending on engine system design) may require lower PGM loadings.

However, medium- and long-term growth opportunities could expand the PGM market but will depend upon market development, new legislation and sponsorship of governments.

Growth potential in the BRIC economies' jewellery sector remains an opportunity; market penetration is low and markets could grow with increasing consumer income and spending but this would require sustained market development. Broadening the scope of vehicle emissions legislation to include new pollutants and other vehicle types (e.g. buses, freight trucks) will expand PGM auto catalyst demand. Similarly energy diversification and independence, and regional environmental pressures are accelerating the shift toward alternative fuels and zero-emissions vehicles. PGM solutions (e.g. fuel cells) could lead to higher demand, but competing technologies include battery electric vehicles which are not expected to use PGMs.

Increased cost of energy and societal change are making PGM-based fuel cell technologies attractive in new industry sectors such as electricity generation, aviation (auxiliary power), portable power units(e.g. substitute for batteries in laptops, cell phones) and marine applications.

Within the Strategic Long Term Planning Framework the key tools to facilitate market understanding and intelligence are:

- The Porter “five forces” analysis;
- Market information in the form of a ‘fact base’;
- An annual industry and competitor analysis; and
- Industry cost curve analysis.

Understanding of the market and the environment in which it functions (part A of Figure 3.1) informs the building of world views or scenarios and the associated global assumptions that are used to develop and optimise the investment centres that comprise the business plan.

The global business environment

Within the PGM industry the global business environment has greatest impact on strategic long term planning in the areas of:

- Emission standards: legislated emission standards underpin the demand for PGMs primarily for autocatalysis.
- Technology: changes in transportation technology will ultimately impact demand for PGMs as the world moves away from fossil fuel dependent internal combustion engines to zero emission technology.
- Global economy: demand for PGMs is inextricably linked to global economic activity.

Emissions legislation has been the key driver of PGM demand since the mid 1990’s. Increasingly strict legislation for vehicle emissions drives and supports PGM consumption for emissions control. However, the positive impact of emissions legislation on PGM autocatalyst demand may now diminish with modest or no further impact from enacted legislation on ~80% of global production.

Increased fuel cost and growing environmental consciousness is accelerating a move towards zero emissions objectives. Despite early challenges to the achievement of zero emissions, adoption of new technology will have an impact on PGM demand. Under these circumstances there would be downward pressure on PGM demand due to limited scope for tightening of emission standards and smaller vehicles unless there was widespread adoption of fuel cell based energy solutions.

Beyond the 25 year window it is inevitable that the next generation zero emission technologies will gain significant market share as infrastructure development matches needs. Autocatalysis would be limited to specific approved applications with an upside potential for the widespread adoption of fuel cells as a primary energy source.

Global economic activity is the driver of consumption of product from the minerals and metal industry. Changes in economic activity have a direct and immediate impact on the industry as they impact demand and ultimately pricing. Anticipating possible scenarios is thus crucial.

The critical aspects of the global business environment must be incorporated into the strategic planning framework in order to align long term investment with probable market demand scenarios. This is done through integration of world views that adequately encapsulate the key global dimensions, into the planning process.

The national business environment

The national business environment is dominated by a legislative environment which has been created to move South African from a racially biased society to a true, majority based, democracy.

The legislative environment is a key enabler of mining and business activities. Acquisition and effective exploitation of mineral assets is predicated on a well defined and effective system of legal tenure that will allow investment in long life assets.

The exploration for and subsequent exploitation of minerals in South Africa is subject to a wide range of legislation and regulation however mineral asset acquisition and exploitation is primarily governed by the Minerals and Petroleum Resources Development Act and associated regulation. The social licence to operate is further impacted by the Mining Charter.

Understanding and operating within the context of the legislation applicable to the minerals industry is thus a requisite for effective business functioning and strategic long term planning.

12.4 Strategic long term planning

The link between the operating context and the planning of exploitation of the mineral asset is that of world views or scenarios (part B of the diagram). These are constructed and used to develop long term planning parameters called global assumptions or GAs that represent the relevant underlying assumptions for each scenario, e.g. metal prices, exchange rates, escalation, etc. These planning parameters inform the financial analysis and optimisation of the strategic long term plan and the business plan.

The annual cyclical business planning process, as represented in part C of the diagram, is then executed using the planning parameters or GAs associated with the preferred or most likely scenario. The composition of the mineral asset portfolio is reviewed relative to the most likely scenario, the current state of execution of projects and company strategic intent. The physical characteristics of the individual mineral assets within the portfolio determine the development of a mine extraction strategy, the mining right plan, the budget and long term plan per asset and collectively for a multi-asset business. Concurrently value is optimised through application of value based management principles during the development of the strategic long term plan – at mineral asset level and company level for a multi-asset organisation.

The business plan, which is the output of the strategic long term planning process, is then reassessed for a possible shift to the next most likely world view. Real options arising from evolving alternate trajectories are evaluated and a contingency plan is developed, based on planning parameters associated with the alternate scenario. This is the link from part C of the diagram back to part B.

The business plan then forms the basis upon which the organisation is structured and resourced. Supporting, aligned execution plans are developed for the necessary supporting activities in finance, human resources, projects, engineering and infrastructure, and sustainable development. All of which takes place in an annual planning cycle.

Execution of this process, in a planning cycle, requires attention to:

- Business strategy definition;
- Scenario planning (world views);
- Definition of long term planning parameters (global assumptions);
- Business value optimisation (value based management for identification and choice of business model options);
- Long term planning procedures (planning cycle, mine extraction strategies, mining right plans, long term plans);
- Capital investment prioritisation, real option analysis and project value tracking;
- Definition of the long term plan and business plan;

- Definition of upside or downside responses (contingency plan); and
- Execution plans for supporting capability:
    - Project portfolio execution;
    - Metallurgical process capacity (smelting, refining ,effluent);
    - Infrastructure (water, electricity, roads, rail, housing);
    - People (skills, motivation, organisational culture); and
    - Community (stakeholder alignment and participation).

These activities are not necessarily sequential, as feedback loops occur between different activities at different points in the planning cycle.

Business strategy definition

No material change is required in the normal, accepted processes and techniques of business strategy definition. However the SLTP framework provides critical input into the initial stages of information gathering (via the world views or scenario process) and in the identification of critical issues/ options facing the business (via the real option analysis process).

Scenario planning (world views)

The scenarios or world views that are developed as part of the strategic long term planning process are integral to the optimisation of the mineral asset portfolio, inform the development of long term planning parameters (the global assumptions) and impact strongly on contingency planning and real options assessment. Critically, the world views or scenarios create the link between the market, the global and national business environments and the utilisation of the mineral asset portfolio.

Dependent on the number of scenarios developed (typically three, maximum four) alternate business options can then be developed with identification of suitable trajectories between scenarios, dependent on changing circumstances or progression between scenarios over time.

The critical difference in approach is rational movement towards an identified and agreed world view (previously introduced through the scenario development process), rather than an ad-hoc crisis driven response. The organisation knows what trajectory to follow as the contingency positions have been previously defined.

Long term planning parameters (global assumptions)

The global assumptions are a set of long term planning and economic parameters that best encapsulate the external drivers of value associated with a scenario or world view to be applied in business planning. The aggregated parameters provide a descriptor of a current and future world view and transition between the two.

Crucially the global assumptions provide the link between the agreed world views or scenarios and the associated economic parameters for business planning purposes.

The global assumptions create discipline and uniformity of assumptions, as they are the only economic planning parameters permitted to be applied across the organisation for planning and valuation purposes. This facilitates comparison and ranking of options.

<u>Business value optimisation (value based management)</u>

The logic inherent in value based management (VBM) is not new to business or the mining industry and has been practised in a variety of forms for several years.

Value based management as a process, within the strategic long term planning framework:

- Provides a set of metrics and a logic framework for value and prioritisation discussions;
- Ensures alignment of objectives, establishes a common language, standards, and processes to align decisions and actions;
- Provides a common approach to setting goals, identifying issues and opportunities, making decisions, allocating resources and taking action; and
- Creates a common set of tools and approaches to understand sources and drivers of value, to prioritise issues and evaluate options.

What is different however is the adoption of the logic and its application to the strategic long term planning framework. The key question that VBM answers in this process is: What is profitable growth, now and in a possible future world view and which of the options should be prioritised?

<u>Long term planning process and procedures</u>

The overall objectives of the long term planning process are to create alignment of activities to a common company planning calendar; to ensure utilisation of common logic and tools that allow comparison between operations and options; to generate a common business plan that drives execution of the company strategy.

The business planning activity creates a central process around which the business organises planning activities to meet the needs of the Executive and the Board. It creates an annual rhythm to activities, so that all parties are aware, through the ‘five Ps’ of the planning process (Philosophy, Programme, Process, Product, and People) as to what must be done, by whom, by when and to what standard to meet the company planning needs. Alignment with support activities is ensured through use of the long term plan as the base plan for resourcing, capability and infrastructure establishment.

The long term planning process ensures optimisation at mining right area level, with strategically aligned constraints, before consolidation and optimisation at a mineral asset portfolio (company) level.

<u>Contingency planning</u>

Contingency planning is the preparation for an unexpected, rapid shift in industry dynamic. Despite development of world views or scenarios, the rate of change between anticipated world views is difficult to anticipate.

Generation of contingency plans (‘Plan B’) allows a rational, controlled shift between one operating state and the next based on earlier analysis. It is a means of reducing the scale of crisis through anticipation and prior sensitisation.

Contingency planning recreates the link between the business plan (part C of Figure 3.1) and the world views (part B of Figure 3.1) by creating an iterative loop based on a different set of global assumptions. This process is real option valuation and drives re-optimisation of the long term plan and the mineral asset portfolio composition in light of a possible alternative world view.

<u>Valuation logic</u>

Definition of a common approach to valuation modelling of capital investment decisions within the strategic long term planning framework is crucial and provides a basis for consistent valuation modelling practice. Discounted cash flow (DCF) methodology is applied with emphasis on net present value (NPV) and internal rate of return (IRR).

Distinction is made between the *capital investment decision* from which consideration of historic / sunk cash flows is excluded, as it has no bearing on the future viability of the investment, and assessment of overall *business performance* where it is necessary to include all past cash flows.

Determination of project value (NPV) is based on the philosophy of a differential value obtained from the difference between the base plan at level 1e (the agreed and financed production, cost and capital profile associated with all investment centres at level 1e and 1 with economic tail management applied) and the base plan plus the project (with its associated combined production, cost and capital profile plus economic tail management), i.e. mine plus project less mine without project.

Valuations are conducted with and without tax shield benefits. Excluding tax shield benefits (stand alone assessment) allows ranking of projects whilst inclusion of tax shield benefits indicates the likely return from the project once included into the overall business plan portfolio.

Inclusion of real option logic into the strategic long term planning process is achieved through:

- Defining world views / scenarios to quantify uncertainty (economic uncertainty);
- Investment centre categorisation by confidence of estimate (technical uncertainty);
- Defining minimum DCF investment criteria (e.g. cost of capital and risk adjusted discount rates) to allow inclusion in the plan;
- Having a defined contingency plan that highlights the relative priority of options (maintain, expand, close, dispose) available for consideration;
- Cyclically evaluating all options within a mining right area (the mine extraction strategy) with the intention that the best option, the option that meets a strategic intent (the business plan constraints) be selected; and
- Continuous transparency within the mining right plan portfolio of investment centres.

Project ranking and prioritisation can be relatively simplistic and based on NPV, short term cash flow and inter-investment centre (spatial) dependencies after any strategic consideration (e.g. mineral right tenure requirements).

Project value tracking

The ability to develop a continuous feedback loop of business investment performance relative to original investment criteria (technical, capital and otherwise) is essential if investment decision making and value maximisation is to be continuously improved. Value tracking of capital investment decisions is thus critical for mineral asset value optimisation and capital prioritisation in large multi investment organisations.

The use of common HSF investment centre models, as developed and applied in the overall short and long term planning process allows integration into existing reporting and governance cycles, and ensures alignment with the overall business planning process.

Execution plans for supporting capability

The ability of a mining company to effectively execute an integrated business plan is dependent on alignment of activities of all participants in the company value chain (Mining, Process, Projects and Engineering, Human Resources, Marketing, Corporate Affairs and Finance).

One of the key objectives of the strategic long term planning framework is to create alignment of activities across functional groupings and along the company value chain. This is facilitated by the integrated process and dependencies created between the business plan and resourcing of the various support functions.

12.5 Application - Anglo Platinum Limited

The example application (see Appendix A) includes the development and implementation of the strategic long term planning framework at Anglo Platinum Limited over the period 2004 to 2009. This is the period during which the conceptual framework, as developed by the author, was implemented for strategic long term mine planning across the company.

During this period significant shifts occurred in market supply and demand, there was a major global financial crisis and three changes in executive management at the company. Despite these changes, the common thread of continuity has been the strategic long term planning process. Anglo Platinum has adjusted and adapted as necessary and retained its position as the premier producer of platinum globally.

Anglo Platinum Limited is the world's leading primary producer of platinum group metals (PGMs) and accounts for about 40% of the world supply of newly mined platinum and more than half of South African supply to the world market (~70%).

The application study considers three periods:

- 2000 to 2003: this creates a context for Anglo Platinum prior to development and application of the conceptual framework;
- 2004 to 2007: implementation of the framework; and
- 2008 and beyond: commentary relating to changes subsequent to the global economic readjustment.

2000 to 2003 – Context

This period is characterised by a strong strategic vision and aggressive growth plan into an expanding market, ambitions that were tempered by a radical shift in global economics following the '9 –11' event in the USA during 2001.

Good progress was made in addressing mineral right tenure risks associated with pending changes in mining right legislation and BEE charters.

The necessary processing infrastructure to meet expansion goals was established (e.g. new smelter at Polokwane) however a cohesive and continuous link between strategic ambition and the ability to deliver the necessary outputs from the mineral assets was not evident.

A review by the major shareholder, Anglo American, in 2003, of ability to deliver against stated intent, in the light of changing global economic conditions, highlighted shortfalls in planning processes. Questions were raised regarding the achievability of the ambitious expansion programmes and several projects began to slide on delivery despite announcements of slowing down of projects in light of the economic conditions.

2004 to 2007 – Implementation of the SLTP framework

During this period of change at the company many of the tools and techniques described in Chapter 11 were developed, refined and implemented as strategic long term planning at Anglo Platinum.

There was no material change in overall business strategy but what was evident was increased integration of activities across the company value chain by virtue of the SLTP activities. This is clearly demonstrated in confidential company strategy documentation.

Value based management was adopted as a key principle for business decisions with companywide training occurring. This has persisted through to current (2010) asset optimisation initiatives.

Regular (quarterly) development and distribution of long term planning parameters in the form of the global assumptions has become standard company practice.

Scenario planning to establish alternate world views or scenarios was implemented with alternate scenarios being manifest in the global assumptions.

The long term planning process and programme has been fully implemented since 2004 with a range of enhancements occurring over time. Company policy and procedures have been established and implemented that embody the key elements of the strategic long term planning framework.

Policy and procedure has been defined and implemented on capital investment prioritisation, the use of real option logic and project value tracking. The project value tracking process and logic provides the basis for reporting of capital projects to the Board.

Development of contingency plan (‘Plan B’) options for each operation and the company as a whole was practised with practical application during 2008.

Execution plans for supporting capability that align with the business plan are well established. Separate water, electricity and road infrastructure strategies and execution plans that integrate with the SLTP outputs are routinely developed. Human resource planning became fully aligned with the business plan during this period.

2008 and beyond

The process that occurred during and subsequent to the global financial crisis and in 2008, 2009 and 2010 is vindication of the soundness of the strategic long term planning framework, systems and processes.

Anglo Platinum, following record performance in the first half of 2008, reassessed the existing 2009 business plan, during the third quarter of 2008, and implemented a SLTP based contingency plan that has allowed continued operations during the global financial crisis and subsequent recovery period.

During this period of global economic crisis, subsequent readjustment and reduced demand, Anglo Platinum has:

- Stabilised production outputs, for the short term (2009 / 2010 / 2011), at the same level as that of 2008 to match anticipated market demand;
- Slowed down execution of capital projects to limit capital expenditure and manage available cash resources;
- Focused on managing costs and improving productivity so as to reduce operating costs and improve overall positioning on the cost curve; and
- Reduced staffing levels through a reduction in contract employees and re-skilling of full-time employees into critical positions.

The strategic long term planning framework logic was utilised to:

- Understand the market – reviewing likely scenarios indicated the probability of a move towards reduced metal demand at a lower price, as anticipated in the 2007 scenario exercise;
- Develop long term planning parameters aligned with probable world views – primarily metal prices, exchange rates, escalation rates, capital availability;
- Apply value based management logic to ascertain the least value destructive options in a decreased demand environment;
- Develop and evaluate contingency plan options in line with the overall VBM approach; and
- Refine, evaluate and execute the agreed plan of action at two levels:
    - Tactical – immediate contingency response using current SLTP data; and
    - Strategic – refinement of the 2009 and 2010 business plan strategic directives to accommodate different world views.

The immediate tactical response was primarily directed at cash flow management and comprised:

- Reassessment and reduction of capital expenditure on expansion projects: All projects in study or execution were reviewed and assessments made of options to slow down or stop execution. Adjusted production and capital profiles were processed through the current HSF models and revised estimates of NPV and cash flow determined. This allowed re-ranking and prioritisation.
- Low cash generative, high break-even cost investment centres (wrong end of the cost curve) were identified and reviewed. Based on this three shaft systems at the Rustenburg mines were placed on care and maintenance following an engagement process with organised labour.
- All contract activities (i.e. non-permanent employees executing non-core activities) were reviewed and aligned with the revised production profile. Concurrently the viability of these contracts over a protracted period of market contraction was reviewed and, where relevant, notice given.

The strategic response was to:

- Redefine an acceptable level of debt during a period of reduced market demand and metal price coupled with a shortage of financing facilities. This translated into a capital constraint, based on a forecast of flat production from 2008 to 2012, applied during subsequent business planning processes.

- Fully review the operating structure of the organisation during 2009 and restructure based on an operating matrix between the centre and the operations. This resulted in a need to reduce staff at the centre and operations in line with a defined staffing structure and productivity levels. This was in due course executed through a voluntary separation process and / or retraining into roles created by the re-adoption of specific contractor activities.
- Reassessment, during the subsequent business planning process, of shafts placed on care and maintenance as an immediate tactical response, using an approach of fix, close or sell.

On the basis of both the tactical and strategic responses, the business plan for 2009 was modified and the business plan for 2010 (developed during 2009 for 2010) was developed taking cognisance of:

- A balance sheet (debt) requirement that translated into a capital expenditure constraint;
- A market driven production constraint to hold production at 2008 levels but from the highest margin sources;
- A working cost objective to maintain working cost flat at 2008 levels for three years through labour productivity improvements and asset optimisation initiatives; and
- Optimisation of installed capacity in all elements of the value chain but specifically process operations.

12.6 Conclusion

The strategic long term planning conceptual framework is a logic construct that translates into a defined outcome – the business plan, through a series of repeated actions, using a standardised set of tools and techniques. It creates discipline and structure to allow shared understanding of the opportunities and challenges facing a mining and metals company. In essence it is a 'way of doing things' - the framework provides the basis for effective management of a large, diverse, complex, mineral asset portfolio whilst creating shared understanding and a common language.

There are no complex equations or processes but a coherent, logical process that integrates various elements, using tools and techniques that are known, or intuitively understood, by most participants – scenarios, discounted cash flow analysis, value based management, project value tracking logic, ranking and prioritisation, option identification and analysis to create order and logic.

It is a logic construct and process that:

- Enables integration between Corporate and Operations, both mines and process operations, and between MRM / Finance / Business Development / Projects;
- Creates a planning process that is routine but sufficiently adaptable, and which allows for planning flexibility;
- Improves the quality of product in long and short term planning by better balance of effort between the two;
- Facilitates communication between stakeholders (Corporate, Operations, Services, Projects);
- Defines the process, its components and inter-dependencies;
- Produces a defined product which is aligned to expectations and allows effective decision making;
- Defines accountability, roles and responsibilities; and
- Ensures delivery of a value optimised, strategically aligned, production profile from the business mineral asset portfolio.

13 LIMITATIONS OF RESEARCH

The intent of this research work was to develop a conceptual framework for the Strategic Long Term Planning of South African PGM operations. The work has been focused on developing a framework for application by holders of multiple mining rights, that will allow effective mineral asset portfolio utilisation in the short and long term.

No formal consideration has been given to the applicability of this framework to other mineral and metal commodities however the principles of the SLTP framework are generic and are broadly applicable across the minerals industry.

The work has been developed and implemented at Anglo Platinum Limited but has not been formally implemented, in its entirety at another mining company. Selected portions of the framework and processes, tools and techniques, have however been adopted by other Anglo American business units and some industry participants.

Opportunity does exist to increase the level of automation of systems associated with the SLTP framework specifically in areas of simulation (e.g. production profiles under different world views) and generation of forecast and actual benchmark data on a short term basis for operational control purposes.

Similarly further work is required (beyond the current prototype) on developing and testing enterprise level optimisation solutions for underground mining operations.

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APPENDIX A - EXAMPLE APPLICATION: ANGLO PLATINUM LTD

A.1 Introduction

The example application utilised is that of Anglo Platinum Limited during the period 2004 to 2009. This period is utilised as this is the period during which the conceptual framework, as developed by the author, was implemented for strategic long term mine planning across the company.

Despite the use of historic data, public domain data and limited confidential company documentation, it has been necessary to restrict some information to ensure requisite company confidentiality. Every effort has been made to ensure that this constraint does not impact on the demonstration of the application of the strategic long term planning conceptual framework to a large, multi mineral asset, PGM mining company. Company communications, for the period 2004 to 2007 in particular, have been included in extract to illustrate the process.

Anglo Platinum Limited is the world's leading primary producer of platinum group metals (PGMs) and accounts for about 40% of the world supply of newly mined platinum and more than half of the South African supply to the world market (~70%). The company is listed on the JSE Limited. At 31 December 2009 the company had 236 840 231 issued ordinary shares (90.3% resident shareholders, 9.7% non-residents). The controlling shareholding (79.7%) is held by Anglo South Africa Capital (Proprietary) Limited.

Anglo American Platinum Corporation Limited (Amplats) was formed in September 1997 as the holding company and sole listed entity for the restructured group of companies that resulted from the unbundling of Johannesburg Consolidated Investments (JCI) and as a result acquired ownership and control of Rustenburg Platinum Mines (Amandelbult, Union and Rustenburg sections), Potgietersrus Platinum and ATOK mines as they were known at the time. This consolidation resulted in a mineral asset portfolio encompassing properties across the Bushveld Complex, Zimbabwe and internationally. In October 2000, the company name changed to Anglo Platinum Limited (Anglo Platinum).

During the period 2000 to 2008 considerable rationalisation of mineral assets resulted from changes in South African mineral legislation; primarily the Mineral and Petroleum Resources Development Act and the Mining Charter. Details are reflected in subsequent sections.

During 2009, Anglo Platinum Limited's mining operations were restructured, with the former Rustenburg Section being split into five mines; Bathopele, Khomanani, Thembelani, Khuseleka and Siphumelele, whilst the former Amandelbult Section was split into the Tumela and Dishaba mines. The Union Mine, Mogalakwena Mine (formerly Potgietersrus Platinum Mine) and Twickenham Mine remained unchanged.

The group has a number of joint ventures encompassing:

- Bokoni mine – On 30 June 2009 Anglo Platinum sold and transferred control to Anooraq Resources (Anooraq) of an effective 51% of the formerly wholly owned Lebowa Platinum Mine (Lebowa) and an additional 1% of the Ga-Phasha, Boikgantsho and Kwanda joint-venture projects to form the Bokoni Mine.
- ARM Mining Consortium Limited, a historically disadvantaged South African (HDSA) consortium, operates the Modikwa Platinum Mine.
- Royal Bafokeng Resources, an HDSA partner, operates the combined Bafokeng-Rasimone Platinum Mine (BRPM) and Styldrift properties (now Royal Bafokeng Platinum).
- The Bakgatla-Ba-Kgafela traditional community, hold a 15% share in Union Mine.
- Eastern Platinum Limited (subsidiary of Lonmin Plc) and its HDSA partner, the Bapo-Ba-Mogale traditional community, and Mvelaphanda Resources operate the Pandora Joint Venture.
- Xstrata Kagiso Platinum Partnership operates the Mototolo Mine.

Anglo Platinum also has pooling and sharing-arrangements with Aquarius Platinum (South Africa), covering the shallow reserves of their Kroondal and Marikana Mines that are contiguous with Anglo Platinum's Rustenburg mines.

The group's smelting and refining operations are wholly owned through Rustenburg Platinum Mines Limited and are situated in South Africa. These operations treat concentrates not only from the group's wholly owned operations, but also from its joint ventures and from third parties.

Elsewhere in the world, the group is developing the Unki Platinum Mine in Zimbabwe and is actively exploring in Brazil. It has exploration partners in Canada, Russia and China.

The company strategy is to create maximum value through:

- Understanding and developing the market for PGMs;
- Growing the company to expand into those opportunities; and
- Conducting business safely, cost effectively and competitively.

Three periods are considered, with comment on the evolution and application of the Strategic Long Term Planning Conceptual Framework:

- 2000 to 2003: This creates a context for Anglo Platinum prior to development and application of the conceptual framework;
- 2004 to 2007: Implementation of the framework; and
- 2008 and beyond: Commentary relating to changes to the company subsequent to the global economic readjustment.

A.2 2000 to 2003

A.2.1 Business strategy

The period from 2000 through to 2003 coincided with a buoyant period for the platinum industry, including Anglo Platinum with steady growth in output and metal prices. It was during this period that company strategy, and the key dimension of being a market driven organisation, was clearly articulated.

An aggressive expansion programme, predicated on rapid growth in PGM demand driven by autocatalysis requirements, was developed to underpin the company vision and strategy at the time.
The strategy being:

- To grow the market for platinum group metals;
- To expand into that growth; and
- To optimise value in current operations.

In the chairman’s statement for 1999 (Anglo Platinum, 1999), shareholders were informed that, owing to the projected growth in demand for platinum and the prospect of diminishing supplies of Russian metal, the group was expanding its operations with a view to achieving a productive capacity of 2.65 Moz by 2003. The increase in production would come, in part from previously announced projects; the Bafokeng-Rasimone Platinum Mine (now Royal Bafokeng Platinum), the Middelpunt UG2 project at Atok (now Bokoni Platinum Mine), and the expansion of capacity at Potgietersrust Platinum Mine (now Mogalakwena Mine). The balance would come from expansion at existing mines and from new projects, including the then recently announced Maandagshoek project (now Modikwa Platinum Mine).

In May 2000, the group announced that its ongoing assessment of supply and demand fundamentals for platinum indicated more favourable medium-term prospects for jewellery, industrial and autocatalyst demand than had been previously forecast and that, accordingly, the Board had decided to increase group production forecast from the 1999 level of some 2 Moz pa of platinum to 3.5 Moz pa by the end of 2006. The additional metal would be sourced from a number of new mines as well as from the expansion of existing mines in South Africa. Anglo Platinum had already informed shareholders that a new mine, Maandagshoek (now Modikwa), producing 162 koz and costing R1.35 billion in 2000 money terms, would come into operation by 2002. Further mines and expansions would be announced as and when they were approved by the Board. The capital expenditure required for the expansion of mining and processing capacity was estimated at R12.60 billion in 2000 money terms, which would be funded from operating cash flows and borrowings. It was further stated that the expansion programme would result in the creation of some 13 000 new jobs and that the considerable investment, together with the significant foreign exchange earnings from the sale of the additional production, would favourably impact on the South African economy to the benefit of all stakeholders (Anglo Platinum, 2000).

Mining authorisation for the Maandagshoek (now Modikwa) south shaft area was received on 6 November 2000 and the first blast was carried out on 9 November 2000. Authorisation for the north shaft was granted in February 2001. Shareholders were informed on 17 August 2000 of a joint venture between Aquarius Platinum (Aquarius), Kroondal Platinum Mines (KPM) and Rustenburg Platinum Mines (Rustenburg) for the expansion of KPM’s capacity from some 100 koz to some 300 koz of platinum per annum, in which KPM and Rustenburg were to share on a 50:50 basis. During the latter half of 2000, Anglo Platinum announced expansion projects to increase the output of Rustenburg and Union Sections by 395 koz and 94 koz of platinum per annum at capital costs of, respectively, R1.3 billion and R423 million in 2000 money terms. Both projects were scheduled for completion in 2002. The mining projects announced would, on completion, augment the group’s production by approximately 1 Moz of platinum per annum (Anglo Platinum, 2000).

Furthermore it was announced on 8 February 2001 that a new smelter complex was to be constructed at Pietersburg (now Polokwane). The complex, which was scheduled for completion in 2002,was estimated to cost R1.31 billion in July 2001 money terms and had a planned capacity of 650 000 t of concentrate per annum. Granulated furnace matte produced at the complex would be transported to Rustenburg for refining (Anglo Platinum, 2001).

Simultaneously a range of international exploration projects were in execution in Canada and Russia.

Concurrently with the aggressive production expansion, significant effort was made to secure mineral right tenure in anticipation of the pending changes in legislation. During December 2000 Anglo Platinum entered into an agreement with the Minister of Minerals and Energy in terms of which Anglo Platinum was granted mineral leases (for 25 years, renewable for a further 25 years) over those farms the group intended mining on the eastern limb of the Bushveld Complex. At the same time Anglo Platinum's mineral rights to certain other farms on the eastern limb, which were held in terms of a joint venture agreement with the former Lebowa State and which Anglo Platinum did not presently intend to mine, were relinquished. The agreement secured for Anglo Platinum, on the eastern limb, those mineral resources required for its production and expansion programmes for the foreseeable future (Anglo Platinum, 2000).

The participation of Black empowerment interests in the platinum industry took tangible form towards the close of August 2000 when Mvelaphanda Platinum (Pty) Ltd (Mvela) acquired a 22.5% in Northam Platinum Limited (Northam). This empowerment transaction was facilitated by Anglo American and the Rembrandt Group. Both Anglo Platinum and Mvela each held 22.5% of Northam's equity (Anglo Platinum, 2000).

Negotiations continued with African Rainbow Minerals (ARM) regarding the Maandagshoek project (now Modikwa) whereby ARM, as the leader of an empowerment consortium, could become a 50% joint venture partner in the project.

During 2001, Anglo Platinum spent R251 million on jewellery promotion and R812 million in commissions and discounts to those users who funded research and development into new applications. This followed a strategic statement that in-situ PGM resources far exceeded demand for these metals and additional PGM demand must be created to give value to these resources (Anglo Platinum, 2001), a clear indication that the Anglo Platinum strategy was being strongly driven by market considerations.

Following a range of scenario studies underlying market assumptions were analysed in the light of a possible recession and, later in 2001, in light of the September 11 attacks in the USA and the ensuing US actions in Afghanistan. It was concluded that, even in the worst case, demand available for Anglo Platinum production by 2006 would remain at 3.5 Moz of platinum (Anglo Platinum, 2001). Under this downside scenario further expansion post 2006 would be limited, although under the best estimate scenario, expansion would continue to be pursued. It is important to note that, in all scenarios examined, it was assumed that competitors would continue with their announced expansions.

The overall strategic context during 2000 to mid 2003 is encapsulated in the following extract from the 2001 Annual Report.

“The Board is pleased to confirm that its growth strategy, first announced in 2000, remains in place. However, it is emphasised that Anglo Platinum is not a swing producer. The Group will do all that it can to use its superior market intelligence to anticipate and then meet future PGM demand, without causing unnecessary instability or volatility by underestimating customers' requirements. Conversely, should markets reach an oversupply situation; Anglo Platinum will not throttle back its expansions for as long as there are more expensive producing rivals on the supply side. To do so would, firstly, be uncompetitive and detrimental to consumers and, secondly, provide a price umbrella to operations that are too costly to deserve to survive. While short-term volatility can result in temporary surpluses and deficits of PGM production, Anglo Platinum is driven by the long-term needs of PGM consumers. Its planning horizon can be several business cycles hence as it decides to build projects that will secure a production base well into the future. Anglo Platinum will expand its production through the establishment of both brown fields and green fields mining operations over unexploited reserves along the Bushveld Complex. In addition, it will construct new smelting and refining capacity in South Africa for the increased arisings of concentrates. Anglo Platinum will also raise efficiencies at existing operations by developing its human resource and mechanising its mining methods; these and other interventions will help improve safety performance. The skills and technologies needed for expansion will be acquired through a combination of aggressive recruitment, intensive training and development programmes, employment equity and supplier partnerships. The strategy also includes a plan to extend Anglo Platinum's industry leadership in respect of environmental care via the ACP and other projects” (Anglo Platinum, 2001, pp.10-11).

During the latter part of 2003, in light of an anticipated change in macro economic conditions, a full review of operations was conducted. Subsequent to this a revised expansion programme was announced based on a stronger than anticipated Rand and lower metal basket price in 2003 compared to 2002.

The review did not alter the view of the robustness of current and future demand for platinum and the need to retain the long-term strategy to grow the markets for PGM products, expand production to meet increased demand and optimise current operations. However it highlighted the combined impact of South African producer price inflation of 26% over the previous three years, an overall 14% decline in the US dollar basket price despite a 9% recovery over 2003, and the 50% appreciation in the value of the Rand from its low of almost R13 to the US dollar in December 2001.

The planned rate of implementation of some of the group's expansion projects was slowed down by between one and three years, in particular Twickenham, Der Brochen, the second phase of the western limb tailings retreatment project, and the Pandora project, to continue expanding treatment, smelting and refining projects to meet the requirements of the build-up in the mining profile and to rationalise existing operations to protect operating margins.

It was, however, still announced that 2.9 Moz of refined platinum would be produced in 2006; effectively an average annual compound rate of growth of 8%.

Overall performance of key parameters, during the 2000 – 2003 period, is indicated in Table A.2.1.

During the period 2000 to 2003:

- Platinum production increased by ~23% in line with the strategic intent to expand into the growing market.
- Similarly PGM production increased by ~28%.
- However there were significant declines in profit margin, EBITDA (earnings before interest, tax and depreciation allowance), ROE (return on equity) and ROCE (return on capital employed) as a result of a drop in net sales revenue per ounce in 2003 and as a result of increased capital investment to fund the expansion (from R1.9bn to R7.4bn).

Table A.2.1 Anglo Platinum – summary statistics: 2000 to 2003 (Annual Report, 2003)

REFINED PRODUCTION		**2003**	**2002**	**2001**	**2000**
Platinum	koz	2 307.8	2 251.1	2 109.2	1 871.7
Palladium	koz	1 190.9	1 115.3	1 049.0	946.6
Rhodium	koz	232.5	211.7	200.4	165.1
Gold	koz	116.1	107.1	102.2	97.9
PGMs	koz	4 161.5	3 947.6	3 673.6	3 255.4
Nickel	000 t	22.1	19.4	19.5	19.2
Copper	000 t	12.9	10.5	10.8	10.8
MARKET					
Average market price	Pt R/oz	5 140	5 567	4 531	3 804
Net sales revenue	R/oz Pt sold	7 017	8 690	8 654	8 287
FINANCIAL INDICATORS					
Capital expenditure	R millions	7 423.6	5 994.1	3 586.1	1 919.7
Gross profit margin	%	23.7	46.5	51.4	54.7
EBITDA	R millions	4 578.5	9 376.1	12 507.4	9 298.0
ROE	%	16.3	45.0	66.2	73.2
ROCE	%	10.5	43.1	64.0	59.0

A.2.2 Comment

This period is characterised by a strong strategic vision and aggressive growth plan into an expanding market, ambitions that were tempered by a radical shift in global economics following the '9-11' event in the USA during 2001. Good progress was made in addressing mineral right tenure risks associated with pending changes in mining right legislation and BEE charters.

The necessary processing infrastructure to meet expansion goals was established (e.g. new smelter at Polokwane) however a cohesive and continuous link between strategic ambition and the ability to deliver the necessary outputs from the mineral assets was not evident. The review in 2003, of ability to deliver against stated intent, in the light of changing global economic conditions, highlighted shortfalls in planning processes. Questions were raised regarding the achievability of the ambitious expansion programmes and several projects began to slide on delivery despite announcements of a slowing down of projects in light of the economic conditions.

A.3 2004 to 2007

The objective of this section is to briefly describe outputs that have resulted from the application of the strategic long term planning framework, as developed by the author, at Anglo Platinum over the period 2004 to 2007. During this period many of the tools and techniques described in Chapter 11 were developed, refined and implemented as strategic long term planning at Anglo Platinum.

Key elements that are covered are:

- Business strategy definition;
- Business value optimisation (value based management for identification and choice of business model options);
- Scenario planning (world views);
- Definition of long term planning parameters (global assumptions);
- Long term planning procedures (planning cycle, mine extraction strategies, mining right plans, long term plans);
- Capital investment prioritisation, real option analysis and project value tracking;
- Definition of the long term plan and business plan;
- Definition of upside or downside responses (contingency plan);
- Execution plans for supporting capability; and
    - Project portfolio execution;
    - Metallurgical process capacity (smelting, refining ,effluent);
    - Infrastructure (water, electricity, roads, rail, housing);
    - People (skills, motivation, organisational culture); and
    - Community (stakeholder alignment and participation).

A.3.1 Introduction

In late 2003, Anglo Platinum and its major shareholder Anglo American plc, conducted an operational review of the company which highlighted the need to move to a centralised and standardised way of conducting business and running operations. Subsequently during 2004, restructuring of corporate and technical support staff was implemented. The objective of the restructuring process, in the technical arena, being to streamline decision making from the corporate head office, provide a central knowledge pool of how various technical functions should be undertaken in the group and assess the competence and capacity of the operational technical support staff.

A critical outcome of this process was the centralising of planning into a strategic long term planning department with the objective of ensuring effective engagement with the operations in terms of strategic long term planning, and the executive committee (EXCO) in terms of strategic alignment, scenario development and evaluation, and capital investment prioritisation.

This restructuring coupled with the progressive implementation of the strategic long term planning conceptual framework, as developed by the author who was recruited for this purpose at this time, resulted in the structured development of a series of integrated (across discipline and time) strategic plans.

A.3.2 Business strategy and market conditions

Overall company strategy remained fundamentally consistent with that established in 2000, to develop the market for platinum group metals, to expand production into that opportunity and to conduct business cost-effectively and competitively.

During the period 2004 to 2007 the PGM market was characterised by a period of sustained growth in gross PGM demand (15.2% or annualised 3.6%), which supported a strategic intent of continued growth into an expanding market. Emphasis was placed on creating a project portfolio that provided a compound annual growth rate (CAGR) of around 3% to 5% per annum to maintain, or marginally expand, market share.

However, net metal demand (after recycling) only increased from 6.53 Moz Pt per annum (recycle 645 koz) in 2003 to 6.68 Moz Pt per annum (recycle 1.59 Moz) in 2007; a net demand growth of 2.3% (CAGR 0.6%), despite the gross demand growth of 15.2%. The reduced net demand resulting from increased recycling volumes associated with increased metal prices and more autocatalysts becoming available for recycling.

During the same period Anglo Platinum expanded production from 2.31 Moz to 2.47 Moz, a CAGR of ~1.8%, missing the strategic growth objective of ~3%. However compounded growth in overall industry supply during the same period was ~1.6%, resulting in Anglo Platinum increasing its market share, of net demand, from ~35% to ~37%.

Progressive record increases in PGM prices coupled with depreciation of the Rand against the US$ created record Rand basket prices (e.g. from R7 649/Pt oz in 2004 to R18 167/Pt oz in 2007). However these price levels fuelled significant escalations in both working cost and capital cost inputs, as competition for scarce resources (skills, equipment and raw materials) developed and pushed out project delivery time lines.

Formal industry and competitor analysis was established with the development of an industry fact base, annual industry and competitor analysis documentation, financial models for major industry participants, Porter's “five forces” analysis and cost curve analysis.

Increased effort was directed towards resolving uncertainty of mineral rights tenure arising from the implementation of the Mineral and Petroleum Resources Development Act and the Mining Charter. This resulted in the disposal of mineral assets in relation to the Bokoni (formerly Lebowa Platinum Mine) and Booysendal transactions.

Anglo Platinum appointed a new CEO in 2003 and further changes in executive management and Board structure resulted following changes in the Anglo American (controlling shareholder) Board in 2007.

A.3.3 Value based management

During 2007, following the appointment of a new Anglo American Group CEO (Mrs CB Carroll), Bain and Company was commissioned to conduct a review of operational practices and establish consistent Anglo group-wide practices in strategic planning.

The principle of value optimisation as the key driver of the portfolio composition in the strategic long term planning process at Anglo Platinum was acknowledged and included in an Anglo American group-wide value based management (VBM) initiative.

This process led to development of training materials and a progressive implementation of VBM as the key driver of business optimisation during the second half of 2007. Senior staff, across Anglo Platinum, were trained by in-house trainers (including the author) in the principles and application of VBM.

A.3.4 Scenario / world view development

Scenario development for SLTP, outside of the processes conducted during Board strategy breakaways, was introduced in 2007. Implementation was originally delayed to allow the primary focus to be placed on establishing planning systems, programmes and processes on operations and formalising the development and issue of long term planning parameters (see subsequent sections) during 2004-2006.

The process and outputs of the 2007 scenario development workshop are provided as example. The process followed mirrors that indicated in Section 11.4.

The strategic conversations during the session attempted to address the following fundamental questions about the future of the PGM industry:

- What will be the needs, choices and possibilities that will shape the global ‘platinum system’?
- How will the ‘platinum system’ look in next three years, 15 years and beyond?

- What roles will competitors, government, society, employees and other stakeholders and the different components of our organisation play in shaping this system?

The core dimensions that were developed and used to define and describe the scenarios were global economic growth and PGM dependency.

Global economic growth: One of the greatest challenges for the PGM industry is to ensure that business models are sustainable across all potential future cycles of global economic growth. There are strong assumptions that the global economy will continue to grow on the back of Asian growth lead by China and India, and contributed to by Brazil and Russia, and that the US and EU, which are critical players will continue along a positive path. If these assumptions were to play out radically differently, the implications for the platinum system could be devastating.

Key global economic issues identified included:

- Globalisation;
- Political stability;
- Dominance by China, India;
- Impact of the US on the global economy; and
- World currency.

PGM dependency: The future of the platinum system by the year 2022 will be robustly determined by PGM demand, which is a key primary driver. This well-debated driver represents a strong global assumption and offers both a challenge and an opportunity for the future of the platinum system. As part of the global energy demand scenario, the utilisation of PGMs could face a slump if new, emerging, innovative and renewable technologies were to be cheaper and manufactured away from traditional platinum based components. In other words the platinum system might face enormous problems, if not extinction, with the emergence of disruptive technologies. Yet there are also tremendous opportunities if the platinum system can adapt to new technology requirements in an alternative energy application or to environmental legislations for greater economic efficiency in the future global carbon market. The scenarios indicate that technology and global environment legislation could be both a threat and an opportunity.

Key PGM demand issues identified included:

- Energy sources / security;

- Energy technology;
- PGM applications;
- Transport choices;
- Environmental concerns;
- R&D; and
- Rate of the change: technological, environmental, etc.

The relationship of these two variables in four world views is summarised in Figure A.3.1

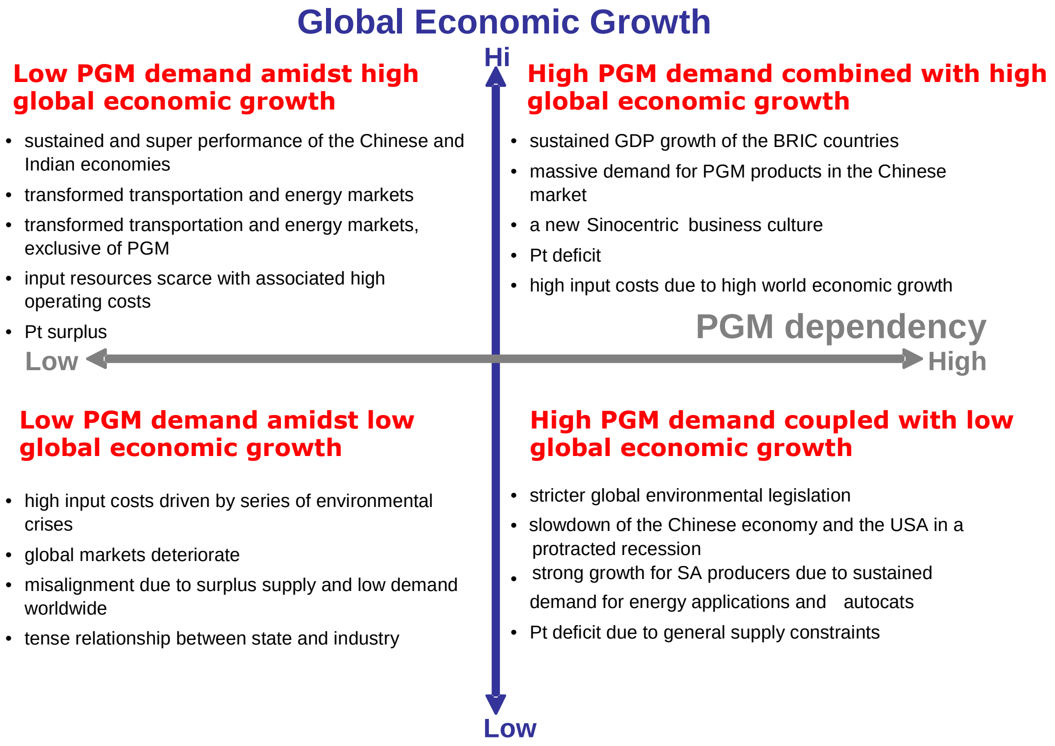


Figure A.3.1 PGM industry – possible world views – 2007

The relationship between these scenarios and the underlying detailed economic parameters that will affect the determination of the global assumptions, as in Figure A.3.1, is shown in Table A.3.1.

Table A.3.1 Scenario factors – descriptions

	Low PGM demand **Low economic growth**	**High PGM demand** **Low economic growth**	**Low PGM demand** **High economic growth**	**High PGM demand** **High economic growth**
Global Economic Growth	Global markets deteriorate	Global slowdown Strong growth for Anglo Platinum	High perceived global growth spurred by China and India	Continued strong growth in the commodity market on the back of China's economic strength unleashes frenzy of global mergers and acquisitions in mining industry
Supply: Demand Balance	Low PGM demand misaligned to surplus supply	Strong demand growth for platinum globally followed by a measured supply side and higher profits for Anglo Platinum, resulting in a deficit supply Pt system	Insatiable global energy demand drives the successful search for alternate fuel technologies, not requiring Pt Low demand for PGM drives a surplus supply situation	Demand side spurred by sustained global growth and rapid penetration of Pt-based fuel cell technology Huge growth in market for jewellery and aesthetic industries where dental alloy health plans are linked to China's demand Looming challenge of keeping up with enormous demand levels resulting in a supply deficit scenario
Supply / Access	Access constrained by resource nationalisation	No supply constraints, and access unlikely to be hampered by countries facing economic hard times, although community issues could constrain access	No supply or access constraints	Supply exhaustion imminent

	Low PGM demand **Low economic growth**	**High PGM demand** **Low economic growth**	**Low PGM demand** **High economic growth**	**High PGM demand** **High economic growth**
Competitive positions	High operation costs driven by environmental crises, including mine safety, force producers to close most marginal mines Anglo Platinum loses market share and profit dwindles Business environment characterised by high taxes, resource nationalisation and centrally controlled suppliers.	Favourable and dominant global position New growth markets for platinum in hydrogen economy (fuel cell components) and steady demand in transport (for autocats) Low economic growth results in low input costs given surplus supply in input resources	Global platinum system under strain as new niche markets emerge out of disruptive technologies PGM and autocats industry and its derivative niche industries struggle to maintain dominant position. PGM prices plummet Ongoing economic growth results in increased operating costs	New Asian executive governance dominates in the global platinum system with new Chinese value-based management style Strong focus on the Eastern customer base and mainly the Chinese consumer Ongoing economic growth results in increased operating costs
Society, governance & stakeholder relations	Significant changes in social behaviour and new sustainable innovations in technology toward the use of PGM Governments nationalise strategic resources, expropriate mineral rights and seize platinum mining operations during state of emergency. Massive lay offs, high unemployment, social unrest and crime	Reasonably good relations as industry enjoys a strong position in an otherwise weak economic climate However industry increasingly coming under pressure to contribute to addressing social disparities worldwide	Platinum system and Anglo Platinum attempt to focus on value chain heavy mechanisation and safety with a socially responsible platinum provider mentality Affluent and ecologically conscious public drive demand for cleaner fuel technology, away from PGMs	South African and the Chinese governments support downstream beneficiation targets set for the PGM industry in South Africa Large migration of Chinese skills around the world, into South Africa and wherever necessary Uplifting social effects on the South African GDP and all educational levels

	Low PGM demand **Low economic growth**	**High PGM demand** **Low economic growth**	**Low PGM demand** **High economic growth**	**High PGM demand** **High economic growth**
Technology	Adoption of divergent technologies and heavy usage of traditional technologies Uneven use of innovative technologies among nations and companies to assert their competitive market position	No substitute for catalytic converters Wide adoption of fuel cell technology utilising platinum components Even if other energy technologies emerge that are not PGM dependent, Anglo Platinum will have capitalised upon a significant stage of fuel cell dominance.	Emerging new and innovative technologies (alternative fuel technologies that are non-carbon based, but no PGM component requirements) create a disruption in platinum demand	Chinese stakeholders fund alternative energy technologies, particularly Pt-based fuel cells Consolidated R&D generates major technological breakthrough in fuel cell technology and the rapid growth in demand for platinum associated with a hydrogen economy
Environment	Fragmented global environmental legislation and free-for-all environmental pollution across the globe Global warming takes place at an alarming rate Disregard for sustainable management of the environment, the global emission trading scheme and the abuse of the carbon market system Pollution levels critically high Natural resources – particularly oil and water – scarce or vulnerable Global warming effects have significantly increased natural disasters, and disrupted infrastructure and logistics	Global environmental compliance creates new sources of opportunities that favour demand for platinum	Environmental pressure groups gain significant global political leverage in international politics and business Emergence of a substantial support from an increasingly affluent and environmentally sustainable literate and highly social conscious public	Limited environmental risks with emerging innovative fuel cell technologies Clean development mechanism applies to all new PGM based technologies

A.3.5 Long term planning parameters (global assumptions)

The methodology for determination of the long term planning parameters (global assumptions) has been defined in Section 11.5. Global assumptions have been fully adopted and utilised as an integral part of business planning. They have been determined and issued quarterly, in support of the SLTP process since 2005. The global assumptions are issued in two forms – as a HSF (Hyperion Strategic Finance – the customised software used for financial modelling) template for automatic integration with investment centre models and further consolidations, and in an excel spreadsheet format.

Owing to the sensitivity of the data contained in the global assumptions it is not possible to reproduce specific data, but the overall format of information contained is indicated in Table A.3.2. Note that the global assumptions are defined by production profile, scenario and by quarter; in this example base, scenario 2 and first quarter (Q1).

Table A.3.2 Global assumptions – data layout

GLOBAL ASSUMPTIONS
Rand Millions, constant money terms 2009

2009 LTP Investment Centre
Base
GA (Q1, S2), IC (Base)

Confidential
(requires approval from SLTP or CFD departments
for distribution outside Anglo Platinum)

IC 10 master v.

Year	No.	CPI		R/$			Tax		Disc. rates	
					Real				Real	
		SA	US	Nominal	2009	2010	SA	Div w/h	NPV	EP
2009	0	7.17%	-0.31%	8.4400	8.4400	8.4400	28.0%	5.0%	0.00%	0.00%
2010	1	6.38%	1.74%	7.5000	7.1729	7.5000	28.0%	5.0%	0.00%	12.50%
2011	2									
2012	3									
2013	4									
2014	5									
2015	6									
2016	7									
2017	8									
2018	9									
2019	10									

Off-Mine Costs (constant 2009)						Off-Mine Costs (real 2010)					
Smelt	PM Ref	BM Ref	Other	PM Trns	BM Trns	Smelt	PM Ref	BM Ref	Other	PM Trns	BM Trns
R/t conc	R/oz 4E	R/t Ni&Cu	R/oz Pt	R/oz 4E	R/t Ni&Cu	R/t conc	R/oz 4E	R/t Ni&Cu	R/oz Pt	R/oz 4E	R/t Ni&Cu

Working Capital					
Stores	AR (trade)	AR (oth)	Creditors	ESB	Tax (curr)
% costs	days rev	% costs	days costs	% costs	% of I/S
3.90%	19.30	6.90%	46.70	0.70%	37.00%
3.30%	20.30	4.60%	48.80	1.00%	28.00%

Year	No.	Escalation rates: Opex		Initial Project Capex: Generic (levels 3, 2c, 2b)			Project Specific (levels 2a, 1e)																	
		On-Mine	Off-Mine	Overall	Mining	Process	1	2	3	4	5	6	7	8	9	10	11	12	13	70	72	78	85	90
				-			Mining	Civils	Struct	Painting	Mech	Platewrk	Piping	Electrical	Instrumt	Consum.	Admin	Serv o/h	Non-prc e	Reimb	Reimb	Reimb	Reimb	Reimb
2009	0	9.67%	11.19%	6.54%	6.45%	6.66%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2010	1	10.98%	11.96%	7.87%	7.55%	8.33%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2011	2	7.89%	9.36%	7.41%	6.80%	8.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2012	3	9.47%	9.74%	8.22%	6.80%	10.19%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2013	4	7.98%	8.16%	8.64%	6.89%	11.05%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2014	5	6.49%	6.58%	5.00%	5.00%	5.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2015	6	5.00%	5.00%	5.00%	5.00%	5.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2016	7	5.00%	5.00%	5.00%	5.00%	5.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2017	8	5.00%	5.00%	5.00%	5.00%	5.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2018	9	5.00%	5.00%	5.00%	5.00%	5.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2019	10	5.00%	5.00%	5.00%	5.00%	5.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

SIB Capex Factor	
Minimum SIB as % of On-Mine costs	
Mining	Conc
0.00%	0.00%
0.00%	0.00%
0.00%	0.00%
0.00%	0.00%
12.00%	12.00%
12.00%	12.00%
12.00%	12.00%
12.00%	12.00%
12.00%	12.00%
12.00%	12.00%
12.00%	12.00%

Year	No.	Metal Prices US$ (constant 2009)													
		Pt	Pd	Rh	Au	Ir	Os	Ru	Ni	Cu	Co	Cr Met	Cr Chem	Cr Fnd	Cr Refr
		US$/oz	US$/oz	US$/oz	US$/oz	US$/oz	US$/oz	US$/oz	US$/lb	US$/lb	US$/lb	US$/t	US$/t	US$/t	US$/t
2009	0	1210	265	1594	973	0	0	0	6.65	2.24	16.82	0.00	0.00	0.00	0.00
2010	1														
2011	2														
2012	3														
2013	4														
2014	5														
2015	6														
2016	7														
2017	8														
2018	9														
2019	10														

Metal Prices US$ (real 2010)													
Pt	Pd	Rh	Au	Ir	Os	Ru	Ni	Cu	Co	Cr Met	Cr Chem	Cr Fnd	Cr Refr
US$/oz	US$/oz	US$/oz	US$/oz	US$/oz	US$/oz	US$/oz	US$/lb	US$/lb	US$/lb	US$/t	US$/t	US$/t	US$/t
1210	265	1594	973	0	0	0	6.65	2.24	16.82	0.00	0.00	0.00	0.00

Year	No.	Commission Discounts %													
		Pt	Pd	Rh	Au	Ir	Os	Ru	Ni	Cu	Co	Cr Met	Cr Chem	Cr Fnd	Cr Refr
		%	%	%	%	%	%	%	%	%	%	%	%	%	%
2009	0														
2010	1														
2011	2														
2012	3														
2013	4														
2014	5														
2015	6														
2016	7														
2017	8														
2018	9														
2019	10														

Metal Pipeline (months)													
Pt	Pd	Rh	Au	Ir	Os	Ru	Ni	Cu	Co	Cr Met	Cr Chem	Cr Fnd	Cr Refr
Months	Months	Months	Months	Months	Months	Months	Months	Months	Months	Months	Months	Months	Months

Year	No.	Smelting Recoveries %									
		Pt	Pd	Rh	Au	Ir	Os	Ru	Ni	Cu	Co
		%	%	%	%	%	%	%	%	%	%
2009	0										
2010	1										
2011	2										
2012	3										
2013	4										
2014	5										
2015	6										
2016	7										
2017	8										
2018	9										
2019	10										

Refining Recoveries %									
Pt	Pd	Rh	Au	Ir	Os	Ru	Ni	Cu	Co
%	%	%	%	%	%	%	%	%	%

A.3.6 Long term planning procedures

Between 2004 and 2007 extensive work was done to develop and systemise the logic, philosophy, tools and techniques of the strategic long term planning framework. This process involved the writing of policies and procedures for the group, relating to strategic planning, progressive on-mine training and alignment processes coupled with the annual delivery of a strategic business plan. During this period nomenclature of the outputs and processes changed, following shifts in the composition of the Executive and adoption of preferred terminology. For example the overall process of developing a strategic long term plan was progressively called strategic planning, long term planning, strategic business planning and currently business planning. However the overall philosophy and approach remained consistent.

Emphasis was placed on:

- Entrenching a single, integrated, cross discipline, planning calendar;
- Developing the rules of the game by defining and documenting procedures;
- Establishing the logic and discipline of single discipline reviews (SDRs) of planning inputs to the SLTP and multidiscipline reviews (MDRs) of the planning outputs;
- Developing and defining the tools and techniques to be utilised. This encompassed planning systems (CADSmine, APMOT), data reporting systems (MRM systems, the LTP applications, etc.), DCF valuation tools (development of customised HSF templates, worksheets, investment centres logic and structure, multi reef and joint venture consolidation logic, global assumptions and prioritisation logic);
- Training – across the developing tools and techniques and provision of annual templates and information resource packs;
- Developing and defining reporting and presentation templates to allow effective comparison between operations during reviews; and
- Ensuring alignment of executive reporting and analysis requirements with the detailed analysis required by investment centre, by reef and by mining right area.

The approach was iterative and based on an annual cycle whereby changes in methodology, tool or technique were developed and then frozen for implementation across one planning cycle. A typical example of this is the annual update of the HSF templates and SLTP presentation templates.

An overview of some of the many procedures developed and applied across the company follows:

- Valuation Modelling of Capital Investment Decisions
  The objectives of this procedure are to clarify and define the preferred approach to on-mine valuation modelling for capital investment decisions and to provide a basis for consistent on-mine valuation modelling practice.
- Long Term Planning Process
  The purpose of this procedure is to systemise the planning process and content of the long term plan (LTP) in terms of specific documents and data required during the long term planning cycle.
- Development of a Mine Extraction Strategy over a Mining Right Area and the Translation into a Long Term Plan
  The objective of this procedure is to provide a practical guide to discipline heads and technical and operational managers for the establishment of a mine extraction strategy over a mining right area granted in terms of the Minerals and Petroleum Resources Development Act, and its subsequent translation into a long term plan. This procedure is to be used by persons involved in mine and process planning, project evaluation and the development of investment proposals within Anglo Platinum.
- Definition of Long Term Economic and Planning Parameters - Global Assumptions
  This procedure serves to achieve the policy of generating and assembling a set of approved planning parameters (also known as global assumptions) for application in all group valuation studies and for distribution to authorised personnel within the group.
- Valuation Modelling Joint Ventures
  This procedure is aimed at assisting planning analysts with the construction of Anglo Platinum joint venture model structures (in HSF), in particular with the consolidation of the Anglo Platinum portion of the operations and the value derived from these operations when operated under a JV agreement.
- Formulation of the ‘Plan B’ Scenario Procedure
  The objectives of this procedure are to define the logic and methodology to develop a view on potential downscaling actions to be adopted should supply-demand not evolve as expected, with the prospect of long term prices falling below long term forecasts; and to assess the likely financial implications of a downside scenario in the context of anticipated investment decisions.

- Monthly Planning at Underground Mines

  The aim of this procedure is to ensure that there is a proper focus on providing rigorous, bottom-up production plans; to ensure that planning is carried out by the correct personnel on the mine; to ensure that monthly plans are in line with the budget and to ensure that where there is a deviation from the budget corrective action is implemented to rectify the deviation.
- Group Guideline Strategy and Planning Project Value Tracking

  The objective of this guideline is to clarify and define the project value tracking (PVT) process, along with the roles and responsibilities of relevant stakeholders, in order to meet management and Board reporting requirements.
- Major Projects Operating Cost Estimation Guideline

  The aim of this standard document is to provide guidance on the method to be used in calculating, estimating and forecasting cash operating costs or expenditures (OPEX) for projects.
- LTP: Multi Disciplinary Audit Procedure

  The aim of this procedure is to ensure the application of an Anglo Platinum approved corporate governance audit of the annual long term planning process and the respective outcomes. The intent of the audit is to foster an attitude of due diligence while ensuring guidance from the respective technical expertise available.
- Valuation Modelling of Capital Investment Decisions - Inclusion of Royalties

  The objectives of this guideline are to clarify and define the preferred approach to on-mine valuation modelling for capital investment decisions with respect to the Minerals and Petroleum Resources Royalty Bill, and to provide a basis for consistent valuation modelling practice.
- Valuation Modelling On-Mine Cash Operating Cost Allocation and Application

  The aim and the objectives of this procedure are threefold: to clarify and define the preferred approach to on-mine cash operating cost (working cost) allocation philosophy; to provide a basis for the consistent application of on-mine cash operating costs in valuation modelling of capital investment decisions (projects); and to define accountability for on-mine cash operating cost estimates within the business reporting process and within the capital investment valuation process.
- LTP: Business Risk Assessment Procedure

  The purpose of this procedure is to provide a methodology for risk assessment of the long term plan (LTP) at each operation or green field project as part of the annual long term planning process and deliverables.

- Mineral Resource to Ore Reserve Conversion
  This procedure assists surveyors, geologists, mining engineers and mine planners (SAMREC Competent Persons) in converting mineral resources into ore reserves.

In addition to company based initiatives, a range of descriptive papers, on the Strategic Long Term Planning Framework and the tools / techniques developed by the author and members of the SLTP department, contributed to a range of industry conferences. Core contributions are indicated in a list of publications resulting from this work in Chapter 2.

Following publication and presentation it is gratifying to note that many of the elements and terminology of the Strategic Long Term Planning Framework are being adopted by a range of industry practitioners. The tools and techniques have been widely adopted across the Anglo American operating units following transfer of expertise and tools. Similarly competing PGM producers have adopted much of the terminology and practice following movement of staff.

A.3.7 Definition of the long term plan and business plan

Owing to the sensitivity of content, it is not possible to specifically demonstrate an example of the company long term and business plan. However the contents pages from the 2006 and 2007 strategic long term plans are indicated in Tables A.3.3 and A.3.4. Typically the content of the plan is articulated in a strategic long term plan document with a number of detailed supporting appendices.

The critical content of the documents is communicated through an executive summary presentation. Typically the content of this presentation covers:

- Review of strategic priorities and alignment;
- Safety – strategy, performance, actions and alignment;
- Market – supply / demand forecasts;
- Production profiles;
- Capacity to deliver; and
- Financial review.

Example charts reflecting typical content are shown in Figures A.3.2 to A.3.5.

Table A.3.3 Example content page – SLTP documentation 2006

APPENDICES

Table A.3.4 Example content page – SLTP documentation 2007

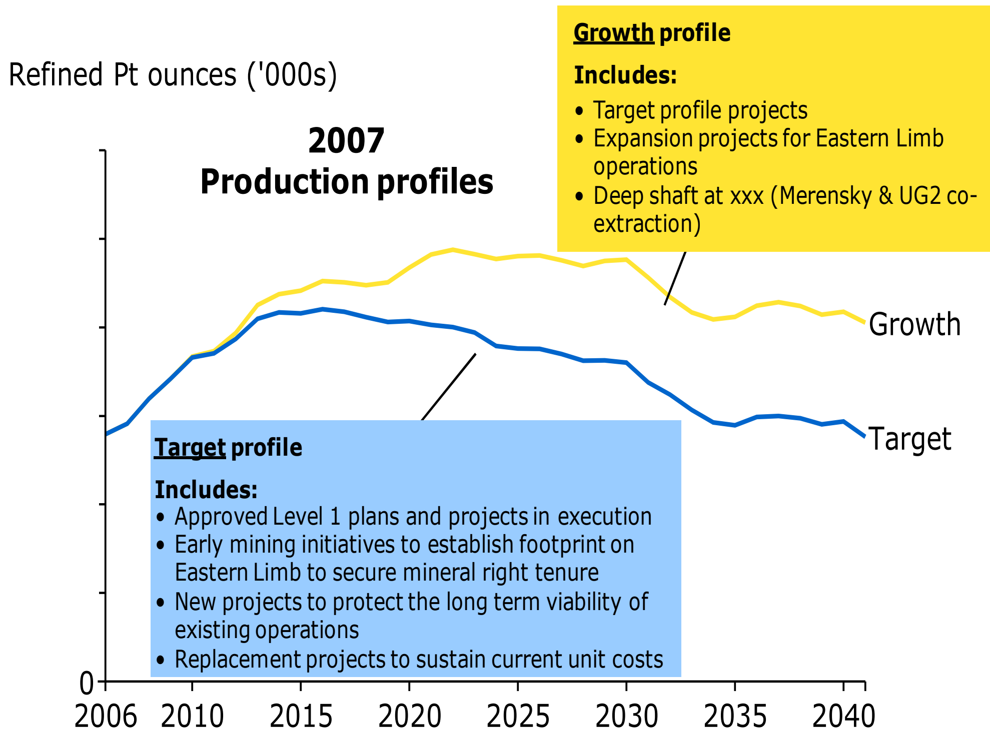


Figure A.3.2 Example – summary SLTP production profiles

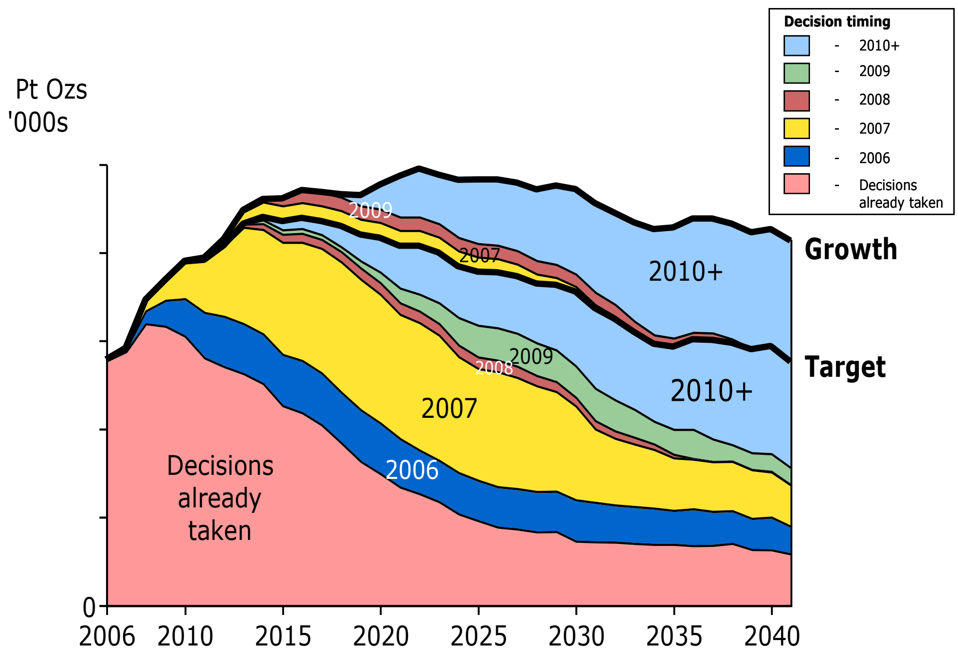


Figure A.3.3 Example – decision timing relating to SLTP profiles

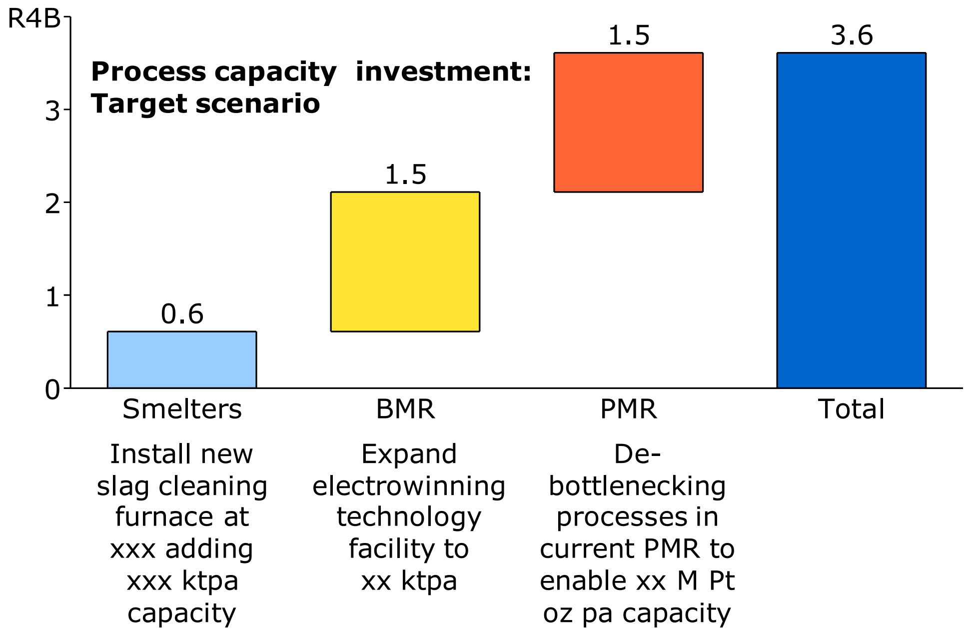


Figure A.3.4 Example – process capacity investment alignment

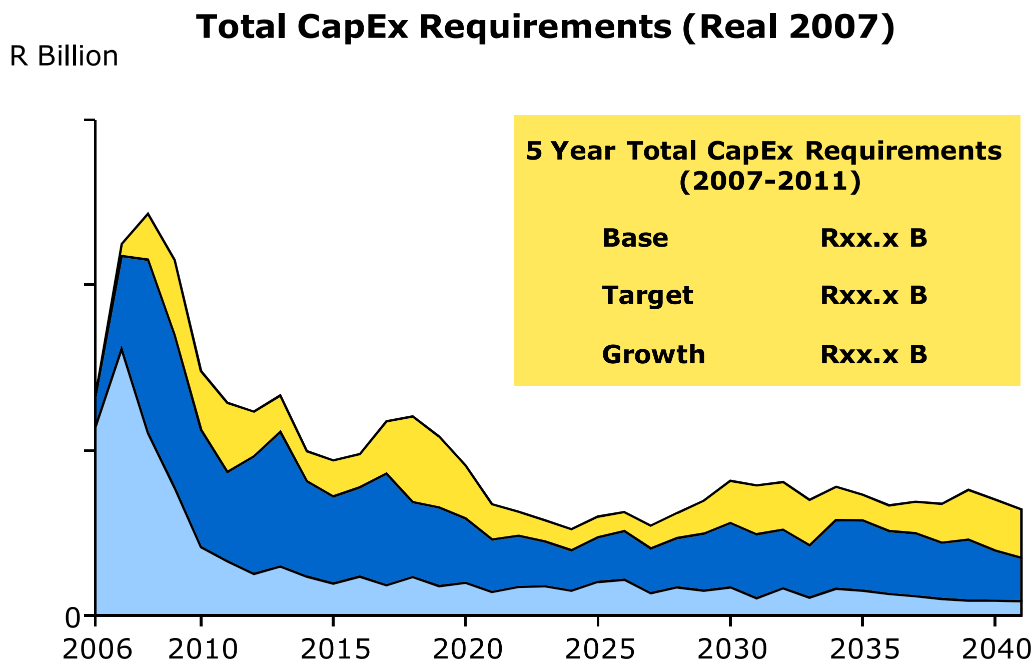


Figure A.3.5 Example – SLTP capital requirement by profile

A.3.8 Capital investment prioritisation and project value tracking

The techniques described in Section 11.9 are applied by mining right area, covering all components in the mineral asset portfolio. The outcomes of the mine by mine ranking, based on the VBM philosophy modified by any necessary strategic imperatives (e.g. mineral right tenure), and the group ranking are represented, initially as a company portfolio as indicated earlier and then on a mine by mine basis. Figure A.3.6 indicates, for a mine, ranked investment centres grouped by possible production profile: base profile (level 1 plus projects in execution), a target / business plan profile (base plus projects to achieve desired market objective within a capital investment constraint) and an unconstrained or growth profile.

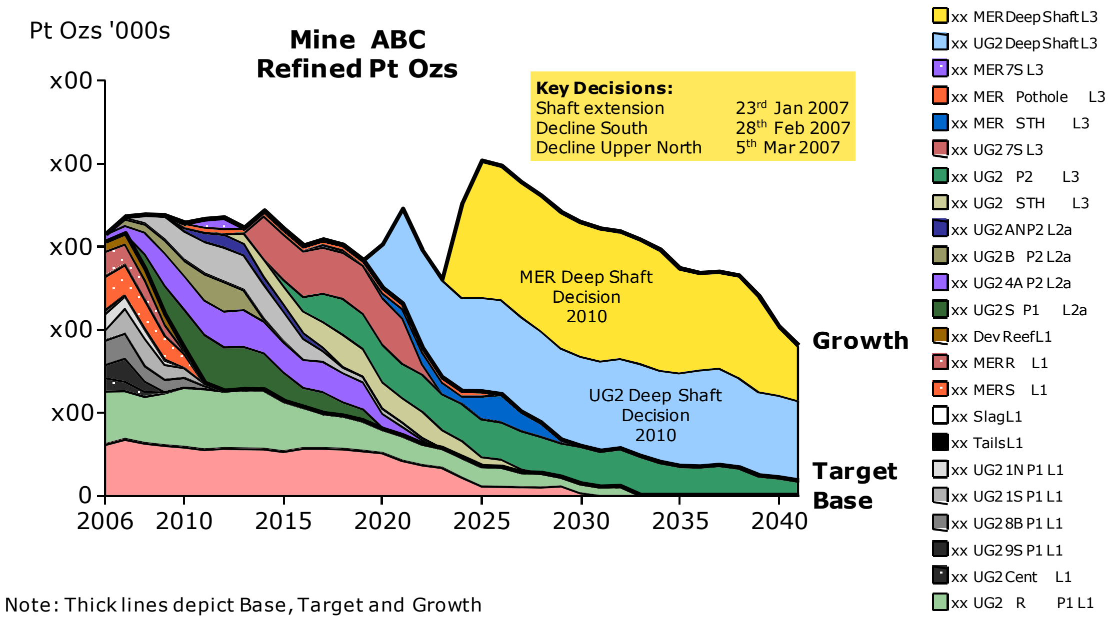


Figure A.3.6 Example – Ranked and grouped mine production profile

A brief description of each investment centre and associated project work is provided (The extracts cited here have been taken from the 2008 strategic long term planning documentation). For example, the then Waterval phase 2 decline project in the Rustenburg area, and the Polokwane smelter, extracts below:

RPM WATERVAL PHASE 2 DEEPENING PROJECT

- Date announced 2005
- Ownership 100% Anglo Platinum
- Average grade 3.08 g/t 4E
- Steady-state Pt oz 74 000 p.a.

Waterval Mine Phase 2 Deepening is the extension of the Rustenburg UG2 Phase 1 Expansion project and was initiated in January 2003. The final Feasibility Study for the completion of the infrastructure to the end of Phase 2 was approved during May 2005, together with a change from a "pure" Room and Pillar mining method into a Room and Pillar with T-cut operation. This increased the grade delivered to the concentrator from 2.86 g/t to 3.05 g/t. Work is well advanced on this project with the "5 barrel" cluster system as well as the associated in-pit mining having been completed to the end of Phase 2.

POLOKWANE SMELTER

- Date announced December 2000
- Ownership 100% Anglo Platinum
- Production commences 2003
- Full production by 2003 (capacity available)
- Full project CapEx R1,45bn (2004 money terms)

Ramp-up to full smelting capacity of 68MW, after replacing the furnace roof and re-commissioning with the redesigned split coolers was achieved in February 2006. The concentrate stockpile associated with the non-availability of the Polokwane Smelter from September 2005 is being processed and should be treated by the 2nd or 3rd quarter of 2006. Two cooler inspections were held in March and May 2006. The copper coolers evidenced a wear pattern similar to that seen to date. Of the test coolers installed, the graphite lined copper shows promise. A full replacement of the upper coolers to lined graphite coolers is planned for July 2006. Due to the new cooler design configuration, and the planned inspection and change out methodology, de-rating the furnace to 45MW is not indicated at this time, as this would constrain the group smelting capacity, and is not in itself a solution to the corrosion mechanism. The second phase (extended annually) of the slag storage pad has been approved with construction scheduled to take place in the winter months.

The production profiles, at group and mining right area level are fully supported with detailed investment centre schedules, by mining right area, for a 30 year period, with supporting process capacity and infrastructure requirements, covering:

- Metal production;
- Capital investment requirements; and
- Financials (cash flow, NPV, IRR, cash margin, break even, pro forma annual financial statements at group level).

Detailed information by investment centre, by reef type can be further extracted from the HSF models as required.

Given that project value tracking, as described in Section 11.10 is routinely conducted in alignment with Board project reporting requirements, typically six monthly, PVT reporting is typically not included with the SLTP documentation but made available as supporting documentation as required.

A.3.9 Definition of upside or downside responses (contingency plan)

The extracts cited here have been taken from the 2008 strategic long term planning documentation. The key requirement identified through the SLTP process was the need for a market contraction or downside response. Sensitive information has been deleted where necessary but the extract still provides demonstration of the application of the technique.

EXECUTIVE SUMMARY

The Strategy Review and Long Term Plan 2008 (LTP08) laid out a growth scenario for Anglo Platinum called the LTP08 Target profile. This profile was accepted as the basis on which to make investment decisions over the next 12 months. With a reasonable degree of certainty, Anglo Platinum believes the market for Platinum will be able to accommodate the additional growth implied by the LTP08 Target profile. However, the LTP08 Target scenario is not without risk. A supply surplus (approximately xxx koz Pt or x% of global Platinum demand in 2008) could be generated under the LTP08 Target profile and the projected global market demand growth and third party supply assumptions. As a result, Anglo Platinum requires a set of "Plan B" actions to be adopted should supply/demand not evolve as expected with the prospect of long term prices falling below long-term forecasts.

Twenty "Plan B" actions have been identified based on an assessment of project NPV, operating cost efficiency, ounce profile and other factors (e.g. strategic importance, ability to "turn on/off" etc.). The overall impact of this downscaling enables a substantial reduction in capital as stay in business capex is avoided and both expansion and replacement capex delayed. Moreover, there may be opportunities to better configure processing capacity given a reduction in ounce profile.

CONTEXT: THE NEED FOR PLAN B

The Strategy Review and Long Term Plan 2008 laid out the growth imperative for Anglo Platinum. Growth is an imperative for three key reasons:

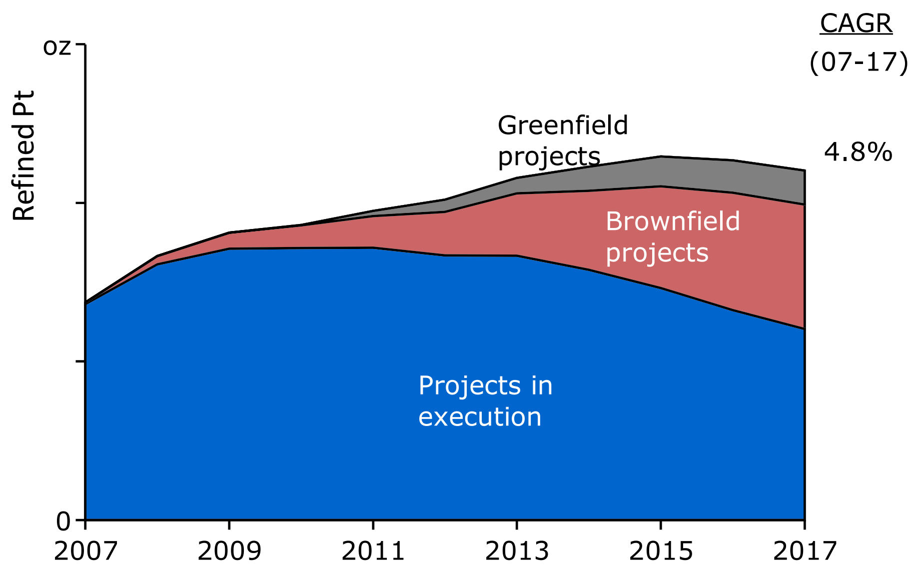
- "Use it or lose it" legislation creates a requirement to establish a greater footprint in the Eastern Limb in order to secure mineral rights
- Next generation deeper vertical shafts are required on the Western Limb in Rustenburg, BRPM, Union and Amandelbult to prevent mine economics deteriorating as the proportion of the more valuable Merensky ore drops. The investment case to develop these shafts deteriorates rapidly over time due to mining lease area boundary issues
- Further replacement projects and/or mine restructuring are required to avoid excessive increases, over time, in unit costs in existing operations.

The production profile that was developed, the LTP08 Target profile, reflects these growth imperatives and the current market environment (see Figure 1). The LTP08 Target profile delivers x.x% CAGR to 2017, peaking at x.x Moz in 2015.

Excluded from this profile are some of the requirements to further secure mineral rights and sustain long term growth in line with current global platinum demand growth at x.x% CAGR to 2016. However these additional projects, which lie outside of the LTP08 Target profile (primarily larger mining operations on the Eastern Limb and some of the next generation deeper vertical shafts on the Western Limb), are less certain, with many of them currently being "out of the money", and further work (particularly on the Eastern Limb strategy, which is in progress) being required to allow them to move forward.

There would also be a concomitant impact on the Process directorate, which would require further capital investment in order to cater for the increased capacity requirements of these additional projects currently outside of the LTP08 Target profile.

Figure 1 – Production profile



Three supply demand scenarios were developed based on the LTP08 Target profile (see Figure 2 – note: not included). Assuming Johnson Matthey forecasts of supply and demand, with a reasonable degree of certainty, Anglo Platinum believes the market for Platinum after a period of sustained supply deficit (1999-2005) should come into balance and could potentially move into surplus in the short-term. However, this surplus will only materialise if Anglo Platinum and third parties achieve forecasted levels of production in what is currently a challenging environment for delivery in South Africa. In the medium-term (by 2013), the market is expected to return to balance/deficit with strong demand offsetting increased supply from new projects. Therefore it is felt that the global Platinum market will be able to accommodate the additional growth implied by the LTP08 Target profile.

However, the LTP08 Target scenario is not without risk. A substantial supply surplus (approximately xxx koz Pt or x% of global Platinum demand in 2008) would be generated under the LTP08 Target profile (see Figure 2 – note: not included).

As a result, Anglo Platinum requires a set of "Plan B" actions (project curtailments, shaft care and maintenance options, and investment delays) to be adopted should supply-demand not evolve as expected with the prospect of long term prices falling below long-term forecasts. Anglo Platinum has sought to identify "Plan B" actions that would balance supply and demand under the current forecast market scenario.

DEVELOPMENT OF "PLAN B" ACTIONS

"Plan B" actions have been developed by determining the logical steps to move toward a lower future output profile from both current operations and future investments. Joint Venture operations, not operated by Anglo Platinum, where the opportunity to influence production is more limited, have been excluded from the review.

Options have been analysed based on the LTP08 completed in June 2007.
There are three primary factors used to drive the prioritisation of potential "Plan B" actions:

1. The market price for platinum (and the associated full basket of metal prices) at which each investment centre becomes NPV breakeven
2. The working cost to revenue ratio for each investment centre as a measure of cost efficiency. This measure ensures differences in the basket of metals by investment centre are considered
3. The potential mine output over the next five years

In addition, a number of further factors have been used to help identify "Plan B" options:

- Strategic factors including potential impacts on mining rights or ability to meet BEE requirements
- Investments required to ensure future mine economics are sustainable
- The ability to effectively mothball Investment centres and restart operations should market outlook improve
- Dependencies between Investment centres and any shared capital expenditure
- The potential to reduce fixed cost and the overall impact on the financials

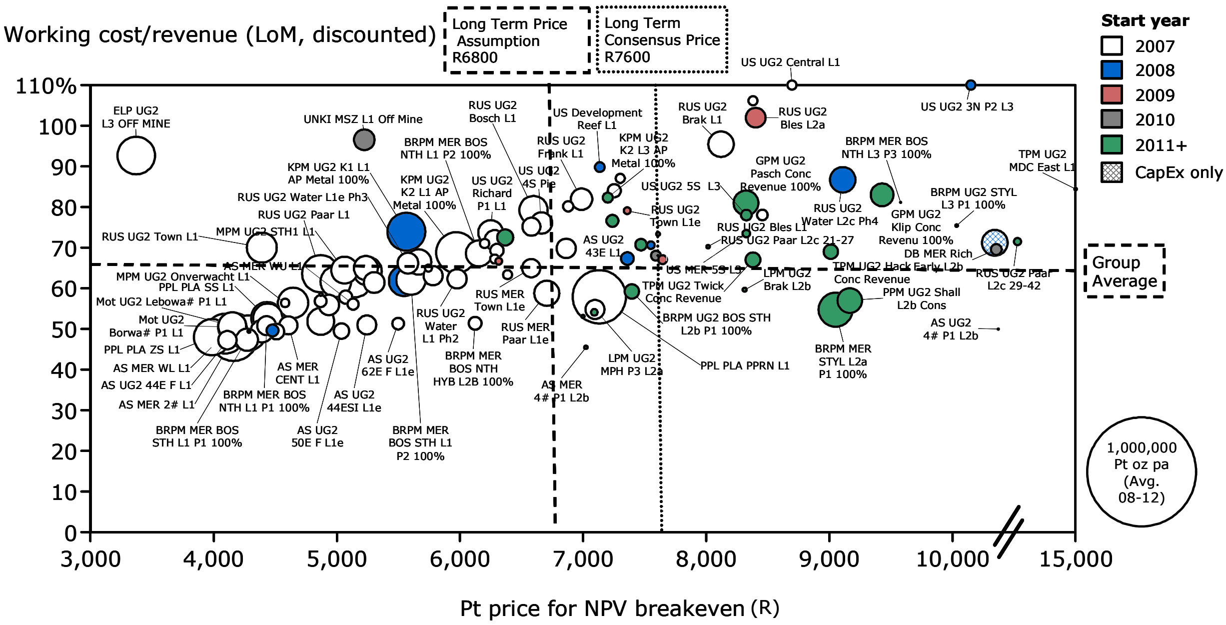
This process identified a series of projects that, while currently unattractive from an NPV perspective, would be required to sustain mineral rights and have therefore not been considered as "Plan B" options.
These are primarily early projects on the Eastern Limb, including projects at xxxxx (at 120 ktpm), xxxxxxx (at 240 ktpm) and xxxxxx (at 250 ktpm). Separately, Anglo Platinum is refining its Eastern Limb strategy with the objective of enhancing the economics of these assets. The xxxx Joint Venture has been excluded from the LTP08 Target profile and was therefore also not considered as a "Plan B" option.

In addition, a number of next generation deeper vertical shaft projects required to ensure the future sustainability of current operations primarily on the Western Limb were excluded as "Plan B" options, even though these projects are currently yielding unfavourable returns.

Both Rustenburg xxxx and Union xxxx shafts have been excluded from the LTP08 Target profile (even though this severely shortens current steady state production output from these operations to no more than a decade into the future) as considerably more project study analysis needs to be completed in order to get these projects to the required levels of confidence. These were therefore also not considered as "Plan B" options.

The three primary factors driving prioritisation are laid out on a matrix (see Figure 3), with the Platinum basket price for NPV breakeven on the x-axis, the working cost/revenue on the y-axis and the average Platinum ounce output over the next five years as the size of the bubble.

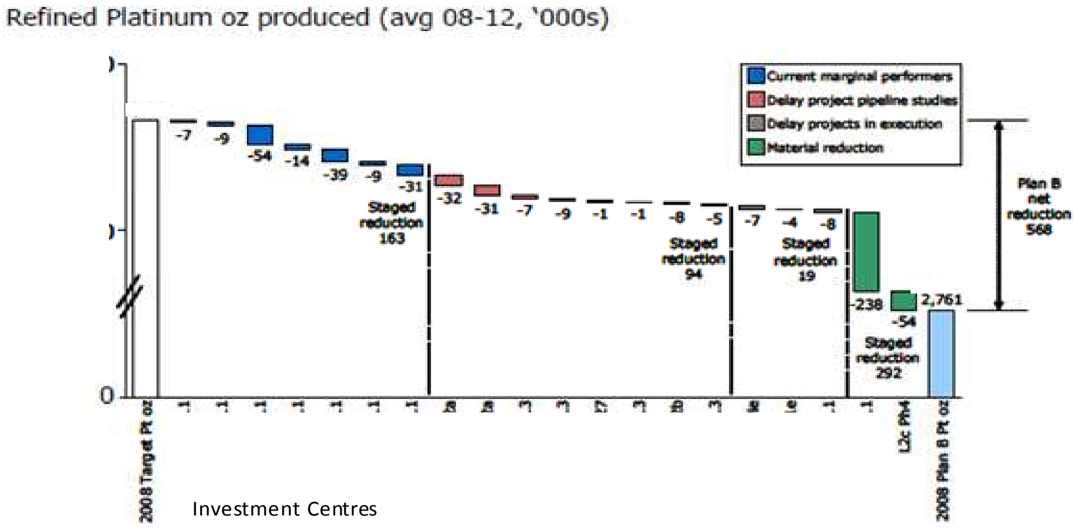
Figure 3 Method for prioritisation of projects



The “Plan B” options fall into four broad tiers (see Figure 4):

- Investment centres presently producing Pt ozs which are currently marginal performers
- Investment centres of project pipeline which could be delayed to slow growth and postpone capex
- Investment centres of approved projects presently in execution which could be delayed to slow growth and postpone capex
- Investment centres which could deliver material reductions in output

Figure 4: Summary of "Plan B" actions

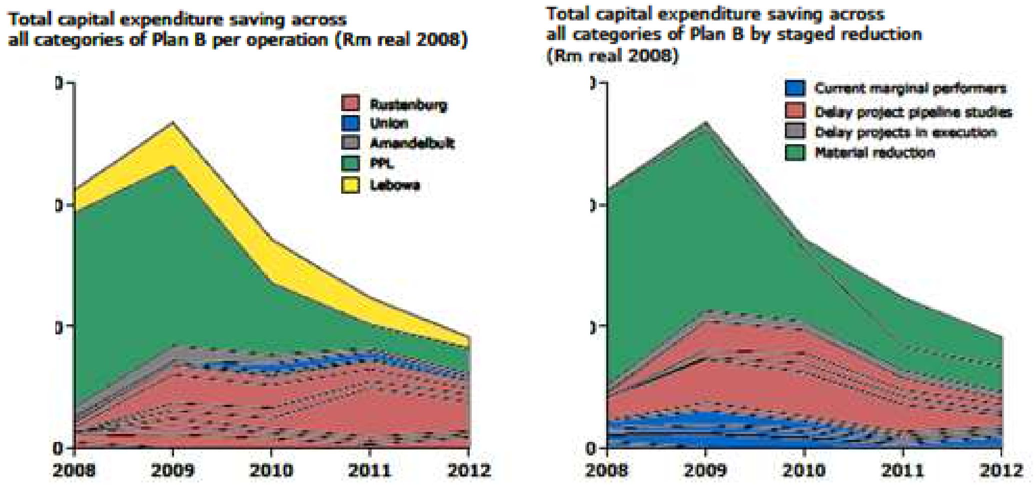


Execution of all twenty "Plan B" actions would almost deliver the required reduction in platinum ounces to balance the projected global market supply demand profile (see Figure 5 – note – not included). In practice, Anglo Platinum would execute only the number of actions required to respond to changing market conditions and these would be tempered by the amount of capital sunk at the time.

If further reductions in production output were required then Anglo Platinum could look at entering negotiations with Joint Venture partners or alternatively select projects or current operations that have a Breakeven Platinum Price below the long term price assumption.

The implications of individual "Plan B" actions have been assessed to determine the overall material impact of the downscaling of mines and delaying of projects, thereby resulting in a substantial reduction in capex, as stay in business capex is avoided and both expansion and replacement capex delayed (see Figure 6).

Figure 6: Implications for capital expenditure



WAY FORWARD

Anglo Platinum will communicate the details of these "Plan B" actions to the relevant stakeholders, and where necessary update the actions to be inclusive of the Budget numbers and incorporate any implications for processing strategy. Going forward, the "Plan B" methodology will be routinely integrated into the annual SLTP process.

A.3.10 Execution plans for supporting capability

Critical consideration is given to the supporting capability and capacity to deliver against the strategic long term plan. This work is undertaken by multidisciplinary teams across each of the executive areas of accountability. Based on agreed production profiles each discipline develops a supporting plan to facilitate execution of the SLTP. In essence each of these plans is the tactical plan of the respective disciplines to execute the strategic intent encapsulated in the SLTP.

An edited extract from the executive summary of a SLTP from the period 2004 to 2007 is provided.

CAPACITY TO DELIVER

Practical constraints

Operational performance is improving (see Volume 2, Chapter 7 – note: not included) and Anglo Platinum is increasingly confident in its ability to deliver value from growth. The capacity to deliver production profiles from a practical basis has also been assessed on six key dimensions:

1. Can Anglo Platinum deliver the capital projects on time?
2. Can the required operational labour be recruited, trained and retained consistent with project timelines?
3. Can housing and bulk services requirements be met?

4. Is there sufficient water?
5. Are there any power constraints?
6. Will Government grant the necessary licences and permits in time?

Overall, assuming actions are taken quickly in a number of areas, constraints should be manageable, albeit recognising there is likely to be some project slippage against current project timescales and additional cost may be required to remove constraints.

Capital projects management: The key constraints from a capital projects management perspective are likely to be around internal resource capacity (mining engineering, project management, engineering, environmental, process engineering) and vertical and decline shaft sinking capacity. Anglo Platinum expects overall capital project management workload to increase by ~10% under the Target scenario and ~30% under Growth with a corresponding increase in resource requirements. Recruiting and retaining these additional resources should be achievable recognising that there will be a productivity impact as new people are integrated and trained and there is also likely to be a cost impact as the market, both in South Africa and globally, for these types of resources is tight and compensation packages required to attract the right people will rise accordingly. An assessment of the supply of vertical shaft sinking capacity in South Africa versus industry requirements over the next ten years suggests the next five years will be particularly tight. Anglo Platinum should be able to gain access to the required resources but this will require providing suppliers with advance notice of requirements and negotiation of preferred supplier agreements which should be completed in Q3 of this year. Decline sinking capacity is also constrained and actions will be pursued to support development of this capacity both internally (CDS) and with its suppliers. There are fewer constraints in terms of Engineering, Procurement and Construction Management (EPCM) capacity and capital procurement, although supply of ultra-large Off-the-Road (OTR) tyres will be tight until 2008 (see Volume 2, Section 6.1 – note: not included).

Operational labour: Western Limb labour requirements are driven by attrition rates as there is limited overall growth of operations. There is a requirement to de-bottleneck the Rustenburg Mining Development Centre facility given current capacity constraints. Eastern Limb requirements under the Target profile are relatively modest given the early mining nature of operations. Under the Growth profile, there is a substantial increase in labour requirement from 2013 with ~9 000 new hires required in 2015 alone. To meet this requirement, the decision has been taken to expand the underground training centre at the Hackney shaft at Twickenham mine and expand the Randfontein Engineering Skills Training Centre. D Grade management is biggest risk with an annual average of 100+ competent managers required to be deployed between 2007 and 2015. A three tiered approach is required: 1) External recruitment; 2) Promote from within; 3) Young Professionals. Plans are also in place to ensure new mining operations are not wholly reliant on novice workforces (see Volume 2, Section 6.2 – note: not included).

Housing and municipal services provision: The biggest housing requirements are in the Eastern Limb. Again, requirements for the Target profile are modest. However, approximately 2 000 houses for C3-E4 Grade employees are required to meet demand for new artisans, supervisors and managers by 2012 under the Growth scenario. The focus for development is in five nodal development centres (Burgersfort, Thabazimbi, Lydenburg, Rustenburg and Polokwane). Making houses available should be achievable. The biggest constraint is procurement of land, particularly in Burgersfort, and current plans are to invest Rxxx M on land procurement in 2006. There are also requirements for social housing in line with the Mining Charter and this will be provided through Sunflower Housing Company (see Volume 2, Section 6.3 – note: not included).

***Water*:** On the Western Limb, water becomes a constraint for Rustenburg operations around 2012 given increases in residential requirements. Current Department of Water Affairs plans are to build a pipeline from Hartebeespoort Dam to meet requirements and Anglo Platinum actions are, and will continue to be, to convert to the use of effluent water at Rustenburg and BRPM. Union requirements will be met by transferring surplus water from Amandelbult or from the Vaalkop Dam. Water becomes a constraint on the Eastern Limb under the Growth profile if the De Hoop dam is delayed by more than 4 years. The current plans are being challenged by SANParks and 4 NGOs given perceived impact on the Kruger Park. Anglo Platinum has the option to develop the Richmond Dam to mitigate against this delay incurring Rxxx M of Capex. The decision does not need to be taken until October 2006 and by that time, there should be a better view on the likelihood of De Hoop being delayed as initial hearings are scheduled for July (see Volume 2, Section 6.4 – note: not included).

Electricity: Distribution and transmission of power are not constraints given recent additions to capacity and comparatively short planning and implementation horizons (12-24 months). However, at power generation level, the national capacity is very tight and will remain so for at least next 5 years, especially during peak times (morning/evening in winter months). Given this, there are likely to be load shedding requirements of Anglo Platinum impacting productivity. However, the requirements of Anglo Platinum are likely to be the same whether Anglo Platinum expands or not, as expansion will have an insignificant impact on national requirements. There is therefore no rationale to delay projects but potential productivity impacts of load shedding are being factored into plans (see Volume 2, Section 6.5 – note: not included).

Government permits: Anglo Platinum is making progress in its applications and approvals of licences and permits to undertake mining operations under both Target and Growth scenarios (Surface Leases, Restitution Claims, WULA/Water Contracts, Land Proclamation and Service Agreements). However, it should be recognised that there are large numbers of applications pending, constrained by Government capacity, and a number of contested restitution claims for individual farms at Pandora, Modikwa and Der Brochen. Anglo Platinum will be supporting Government as best it can to process applications. Any delays in obtaining licences and permits, which are probable, could lead to delays in project implementation, increase the risk to Anglo Platinum if decisions were taken to proceed without necessary approvals and could drive incremental cost to settle disputes. There is a clear imperative to manage government relations at a strategic level (see Volume 2, Section 6.6 and Chapter 8 – note: not included).

In summary, the biggest potential constraints/risks are:

- Internal skilled resources (esp. Mining, engineering and operations D Grade employees)
- Vertical and decline shaft sinking capacity over the next 4 years
- Ability to hire and train appropriately skilled workforce on the Eastern Limb
- Access to water in the Eastern Limb should the De Hoop dam be delayed
- Government delays in granting required approvals

None of these constraints should be deal breakers but they do imply potential delays, increased cost and risk.

A.3.11 Comment

The development and refinement of the strategic long term planning framework between 2004 and 2007 coincided with stabilisation in the platinum market which benefited from a period of sustained growth in demand of ~3.6% per year. Following definition of the broad framework, effort was directed at establishing common processes and systems across multiple operations.

The core manifestation of strategic long term planning was the annual strategy report. These annual Board documents were developed and enhanced year on year as the SLTP process matured along with a deeper understanding of the overall philosophy. Key to this evolution was an increased understanding of how the market characteristics influenced metal demand and price. This thinking translated into improved scenario or world view development and application in the global assumption parameters.

Within the overall value chain close integration occurred between mining, processing and projects, and engineering and infrastructure activities in development of the business plan. Areas for improved integration were in human resource planning (specifically the timing and availability of critical skills) and community engagement and development. Significant conflict was developing between local communities and operations, despite material corporate social responsibility investment. Concurrently poor safety performance, resulting in safety stoppages that had not been included in the original planning, was impacting on delivery.

Despite a radical change in senior management and Board structure in mid 2007, the strategic long term planning framework was retained as the core strategic planning process.

A.4 2008 and beyond

The objective of this section is to demonstrate how Anglo Platinum responded, in the context of the Strategic Long Term Planning Framework, to the global financial crisis of 2008. Unfortunately owing to the sensitivity of company strategy following the global financial crisis it is not possible to provide any detailed information or extracts from planning documentation.

A.4.1 Background

The global financial crisis in 2008 has had a lasting impact on the structure and nature of the global financial industry. The resultant shortage of capital for investment in the mining industry has fundamentally reshaped the strategic plans of many mining and metals companies.

The year 2008 was a year of two parts with the strong demand and record prices of the first half rapidly falling as the global economic crisis took hold in the last quarter and commodity prices went into freefall. The overall tactical response by most companies was to reduce capital and operating expenditures and manage production levels to match market requirements.

The first quarter of 2009 saw significant announcements on mine closures, production cuts or moves to place mines on care and maintenance, coupled with extensive capital deferment and planned redundancies.

The key learning out of this process has been that:

- Increased volatility (metal demand and price) is likely during the recovery period;
- It is important to preserve cash, yet at the same time not stifle the recovery by not investing in future production capacity;
- Increased flexibility is crucial – strategic and tactical, to manage the risk associated with increased volatility;
- Resilience needs to be built into the organisation through positioning of operations at the lower end of the cost curve;
- Social and environmental pressures are likely to increase as a result of the changed perception of risk by society and communities; and
- Organisational flexibility is likely to result from changes in how investment decisions are made, how the business is structured, cost positioning and through improved understanding of the market.

A.4.2 The PGM market (extracts from Annual Report, 2009)

"During 2008 strong autocatalyst and investment demand, primarily from the newly introduced exchange traded funds (ETFs), led platinum to the record level of $2 276 per ounce in March 2008. The high metal prices in the first half of the year also resulted in intensified efforts to thrift platinum group metals (PGMs) from catalyst systems and to substitute cheaper palladium for platinum. Palladium benefited from its high price differential with platinum and from developments in technology, thereby increasing its share in the diesel market. In the second half of the year, the global economic down turn reduced credit availability for vehicle purchases. Metal purchases by platinum jewellery manufacturers declined materially as a result of the high prices and there was a corresponding increase in the use of recycled jewellery metal. Investment and speculative interest declined rapidly in mid-2008, with a substantial sell-off in physical platinum (coins and bars) in Japan, large disinvestment in platinum ETF units in Europe and reductions in net long positions on the New York Mercantile Exchange and the Tokyo Commodity Exchange. This sell-off and reduction in net long positions led the rapid price decline in platinum, to well below $1 000 per ounce by October 2008.

The unprecedented volatility in platinum demand and price experienced in 2008 was followed by a period of consolidation in 2009. The inherent strength in the structure of the platinum business saw the platinum market return to balance during 2009, as jewellery and investment demand increased, reacting to lower price levels in the first half of the year and as investor sentiment improved. These increases offset depressed demand for metal for use in autocatalysts because of reduced vehicle production and lower demand from the industrial sector."

A.4.3 The Anglo Platinum response to the global financial crisis

Anglo Platinum's record financial performance in 2008, for the third consecutive year, was chiefly the result of exceptionally high platinum group metal prices in the first half of the year. The global economic crisis followed a period of high demand and had a major impact on the platinum business. At the beginning of the year, the price of platinum rose to US$2 276 per ounce; within six months, it had dropped to below US$800 per ounce.

Financial performance for 2009 was disappointing compared with that of 2008. This was the result primarily of significantly lower prices for platinum group metals throughout most of the year as overall production, at 2.45 Moz of refined platinum, was essentially the same as 2008.

During this period of global economic crisis, subsequent readjustment and reduced demand, Anglo Platinum:

- Stabilised production outputs, for the short term (2009 / 2010 / 2011), at the same level as that of 2008;
- Slowed down execution of capital projects to limit capital expenditure;
- Focused on managing costs and improving productivity so as to reduce operating costs and improve overall positioning on the cost curve; and
- Reduced staffing levels through a reduction in contract employees and re-skilling of full-time employees into critical positions.

A.4.4 Strategic long term planning – flexibility of response

During the second quarter of 2008, despite benefits resulting from increased PGM prices, considerable concern was developing regarding the sustainability of metal price levels.

The strategic long term planning framework logic was utilised to:

- Understand the market – a review of likely scenarios indicated the probability of a move towards reduced metal demand at a lower price, as anticipated in the 2007 scenario exercise;
- Develop long term planning parameters aligned with probable world views – primarily metal prices, exchange rates, escalation rates and capital availability;
- Apply value based management logic to ascertain the least value destructive options in a decreased demand environment;
- Develop and evaluate contingency plan options in line with the overall VBM approach; and
- Refine, evaluate and execute the agreed plan of action at two levels:
    - Tactical – immediate contingency response using current SLTP data; and
    - Strategic – refinement of the 2009 and 2010 business plan strategic directives to accommodate different world views.

<u>Tactical response</u>

The immediate tactical response was primarily directed at cash flow management and comprised:

- Reassessment and reduction of capital expenditure on expansion projects: All projects in study or execution were reviewed and options to slow down or stop execution were assessed. Adjusted production and capital profiles were processed through the current HSF models and revised estimates of NPV and cash flow determined. This allowed re-ranking and prioritisation.

- Low cash generative, high break-even cost investment centres (wrong end of the cost curve) were identified and reviewed. Based on this three shaft systems at the Rustenburg mines were placed on care and maintenance following an engagement process with organised labour.
- All contract activities (i.e. non-permanent employees executing non-core activities) were reviewed and aligned with the revised production profile. Concurrently the viability of these contracts over a protracted period of market contraction was reviewed and, where relevant, notice was given.

Strategic response

The strategic response was to:

- Redefine an acceptable level of debt during a period of reduced market demand and metal price coupled with a shortage of financing facilities. This translated into a capital constraint, based on a forecast of flat production from 2008 to 2012, applied during subsequent business planning processes.
- Review the operating structure of the organisation during 2009 and restructure based on an operating matrix between the centre and the operations. This resulted in a need to reduce staff at the centre and operations in line with a defined staffing structure and productivity levels. This was in due course executed through a voluntary separation process and / or retraining into roles created by the re-adoption of specific contractor activities.
- Reassess, during the subsequent business planning process, shafts placed on care and maintenance as an immediate tactical response, using an approach of fix, close, or sell.

On the basis of both the tactical and strategic responses, the business plan for 2009 was modified and the business plan for 2010 (developed during 2009 for 2010) was developed taking cognisance of:

- A balance sheet (debt) requirement that translated into a capital expenditure constraint;
- A market driven production constraint to hold production at 2008 levels but from the highest margin sources;

- A working cost directive to maintain working cost flat at 2008 levels for three years through labour productivity improvements and asset optimisation initiatives; and
- Optimisation of installed capacity in all elements of the value chain but specifically process operations

A.4.5 2009 – readjustment to the changed market conditions

During 2009 Anglo Platinum experienced challenging market conditions. However this period of global readjustment was used as an opportunity to reconfigure the operating cost base, improve productivity and take a significant step forward in safety improvement. Financial results were significantly below those of previous years, however operating performance improved and production and sales increased marginally whilst keeping unit costs essentially flat. As a result productivity improved significantly compared with that in 2008.

During the year a more efficient matrix, management structure was implemented and the mines restructured into smaller, more manageable units. The total labour force was reduced, mainly through a reduction in contractors, whilst advancing a values-based company culture programme and improved relationships with external stakeholders.

Restructuring

A major restructuring of mining operations, announced early in 2009, was completed by year end. Rustenburg and Amandelbult were split into more efficient stand-alone units, of five (Bathopele, Thembelani, Khuseleka, Khomanani, Siphumelele) and two (Tumela, Dishaba) mines respectively.

The new structure was designed to create a sustainable reduction in unit costs and to maximise value from assets. Head and regional office complement was reduced by 724 people in 2009, bringing the total reduction to 1 150 since July 2008. Overall labour complement was reduced by 15 752 people during the year or by 18 786 from October 2008. In spite of the significant reduction in employees and the associated challenges, there was not any industrial action and no forced retrenchments. This is only possible when there are sound and robust relations with employees, partners and the unions.

Concurrent with the restructuring, three high-cost shafts were placed onto care and maintenance to optimise overall cost per ounce produced.

The logic applied in this process comprised:

- Maximisation of output from existing infrastructure including approved projects (where the mineral asset supports this);
- Minimisation of cash working costs to improve relative position on the industry cost and margin curve;
- Stopping production from the least viable mining units and placing them on care and maintenance subject to further assessment on a fix, close or sell rationale;
- Minimisation of short term capital investment into infrastructure;
- Delaying of replacement ounces capital investment (new shafts) without compromising optimal output levels (scale effect); and
- Organisational restructuring (concentration of activities plus organisational design) to improve labour efficiency and asset utilisation against industry benchmarks.

Operating costs

Unit cost of production remained essentially flat in 2009 relative to 2008 at R11 236 per equivalent refined platinum ounce. Labour productivity levels increased by 13%, compared with 2008, to 6.33 stoping m^2 per total operating employee per month.

Cost management is being institutionalised with the intent to keep unit costs flat during 2010 and 2011. These real cost improvements will be delivered through improved productivity, value engineering and effective cost management, focusing on supply chain escalation management, the elimination of wastage and reducing allocated costs.

Capital expenditure

Capital expenditure for 2009 included R6 billion spent on projects and R3.7 billion on stay-in-business capital (SIB). A number of projects have been delayed to optimise capital spend rate, the most significant being:

- Amandelbult no. 4 shaft (now Tumela 4 shaft); and
- Twickenham Platinum Mine.

Black Economic Empowerment

During 2009 Anglo Platinum successfully completed three black economic empowerment transactions with Mvelaphanda Resources Limited, Anooraq Resources Limited and Royal Bafokeng Resources (Proprietary) Limited.

Organisational culture transformation

In July 2008 the leadership team of Anglo Platinum, comprising management and unions, studied the corporate culture and identified a number of areas for improvement to meet the challenges facing the organisation. A values programme was launched to encompass every human interaction within Anglo Platinum, and with their stakeholders. A leadership academy was established to more efficiently fast-track the skills transfer necessary for frontline supervisors and middle management. The academy is supported by a personal change workshop programme that aids the creation of a culture in Anglo Platinum appropriate for success in a modern South Africa.

Outlook

Notwithstanding the current uncertainty in the global resources and platinum sectors, the long term strategy, remains sound:

- To develop the market for platinum group metals;
- To expand production into that opportunity; and
- To conduct business safely, cost-effectively and competitively.

Despite the profoundly negative impact of the global economic downturn on the platinum industry in the short term, managing the business with regard to long-term demand expectations remains critical. Platinum remains a strategic industrial and premier jewellery metal and the long-term fundamentals of the platinum industry remain sound.

Based on a sound strategic planning process, Anglo Platinum will continue to respond to the challenges that face the platinum industry. Planned levels of platinum production can be appropriately adjusted should economic conditions affecting net platinum demand change. Production levels continue to be monitored against global economic developments and adjusted as necessary. The combination of the reduction in capital expenditure and of cost-reduction initiatives was expected to reduce the rate of increase in net debt during 2009 and 2010 and improve overall balance sheet strength.

A.4.6 Comment

The process that occurred during and subsequent to the global financial crisis and in 2008, 2009 and 2010 is vindication of the soundness of the Strategic Long Term Planning Framework, systems and processes.

The key components of the framework, as described in Section 11, were applied to carry the company successfully through the worst economic crisis since the Great Depression, viz:

- The global and local context, markets and value based management analysis informed the development of world views which provided the context for the analysis of the long term planning process.
- The output of the long term planning process was then assessed in the context of the most likely world view and a contingency plan defined for any shift to the next most likely world view.
- The business resourced itself to execute the agreed long term plan in the context of a business plan (projects, metallurgy, infrastructure, people, and community).
- Annual reassessment of the mineral asset portfolio is based on the current state of execution of projects and real options arising from evolving alternate trajectories.

A.5 Concluding comment

This appendix demonstrates, through selected examples, the utilisation of the strategic long term planning framework at a large, integrated, multi mineral asset mining company. The simplest, complete demonstration of the application would be to provide copies of the annual strategic long term planning documentation. However owing to confidentiality restrictions associated with a publically listed company, this is not possible and extracts have been utilised where possible.

The efficacy of the philosophy and the processes, tools and systems developed to implement the framework have been demonstrated by continued application and refinement through the period 2004 to present. During this period significant shifts occurred in market supply and demand, there was a major global financial crisis and three changes in executive management at the company. Despite these changes, the common thread of continuity has been the strategic long term planning process. Anglo Platinum Limited has adjusted and adapted as necessary and retained its position as the premier producer of platinum globally.