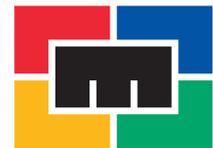


MODERNISATION: TOWARDS THE MINE OF TOMORROW

Fact sheet



**MINERALS COUNCIL
SOUTH AFRICA**



“Modernisation will help to improve safety and health, facilitating the quest for zero harm.”

QUICK FACTS

Modernising the mining industry involves:

- 01** Turning to account South Africa's mineral resources in the safest, most efficient, cost-effective and sustainable manner possible
- 02** Recognising that people are at the heart of our industry with focus on improving skills, health, quality of life and fulfilment of employees
- 03** Conservation of natural resources, preservation and restoration of the environment
- 04** Contributing to the development of local and labour-sending communities
- 05** Recognising that metals and minerals are valuable, useful and necessary
- 06** Transformation and growth as key imperatives of the mining industry and nation

The South African mining sector has, for more than 100 years, been considered a labour-intensive industry using physically demanding manual drilling methods with blasting and cleaning on a stop-start basis, predominantly in narrow reef, hard-rock mining for gold, platinum and chrome.

Working conditions are generally characterised by abrasive rock, steep gradients and seismicity. And, with increasing depth, the virgin rock temperature continues to rise. On the Witwatersrand Basin, which is host to the world's largest gold resource, the virgin rock temperature at depths of 2,000 metres below surface can be as high as 40°C. On the Bushveld Complex, which is host to 80% of the world's platinum reserves, these temperatures are even higher, reaching 70°C.

Today, most deep level underground mines are aging with travel times to the face sometimes reaching an hour or more. Consequently, with increasing depth and distance from the shaft, actual drill time at the workface has contracted, accounting for greater health and safety challenges, shrinking production and contributing to burgeoning costs.

The recent volatile price environment has been exacerbated by rising costs and decreased productivity.

Modernisation will help to improve safety and health, facilitating the quest for zero harm. It will also contribute to increased skills development, employment, exports and revenue; not to mention the knock-on effect on local communities. Ultimately, without a shift in mining methodology, the industry will fail to mine South Africa's deep-level complex orebodies profitably. This could result in the sterilisation of resources, accelerated and premature mine closures and job losses. Research suggests 200,000 job losses by 2025 could affect 2,000,000 people indirectly.

RESEARCH AND DEVELOPMENT

In part, modernisation will be driven by technological innovation, which in turn needs to be driven by research and development (R&D). To be successful, however, it needs to be addressed in a holistic manner, adopting a systems and people-centric approach. All elements of mining – including reporting structures, skills development, change management, stakeholder engagement, community development and environmental management – need to be modernised.

WHAT HAVE WE DONE?

While a number of individual products have been developed by private companies, mining companies and manufacturers, an integrated suite of locally manufactured products with real-time monitoring and control is needed. The industry has set a milestone for the implementation of a cyclical drill and blast suite of equipment that mechanises all activities in the stoping and development cycle, including remotely operated equipment. In addition to this milestone, the following research areas have been identified as critical to the development of R&D needs in the mining industry:

- Work done to date indicates that such modernisation significantly extends mine life, preserves mining employment, improves safety and health, and allows mining of lower-grade orebodies and deeper resources. This also creates an environment conducive to 24/7 operations until 2045 and beyond in the gold sector, higher skills utilisation and job preservation.
- With new equipment, which allows the conventional drill, blast and clean cycle of working, work can be done 24/7 by miners skilled in the use of remotely controlled equipment from safe, healthy sites.
- While all mines differ from one another, it is possible to predict the effect that this might have on a low-grade gold ore resource, totalling 400Mt, which is amenable to profitable extraction using mechanised techniques. In addition, there are some 160Mt of high-grade ore locked in underground support pillars, accessible from current infrastructure. At least double could be mined below current infrastructure using appropriate technologies.

A low-grade mine with a current conventionally mined life expectancy of some four years, using semi-mechanised methods, could extend operations to 15 years and, with full mechanisation and 24/7 operations, to as much as 25 years.

“A low-grade mine with a current conventionally mined life expectancy of some four years, using semi-mechanised methods, could extend operations to 15 years.”

WHAT DO WE MEAN BY MODERNISATION?

Modernisation is not simply mechanisation and/or gradual implementation of new technology. It is not the replacement of people with machines. It is not a euphemism for job losses.

It is a process of transition and transformation of the mining industry of yesteryear and today to that of tomorrow.

Modernising the mining industry involves:

- Turning to account South Africa’s mineral resources in the safest, most efficient, cost-effective and sustainable manner possible
- Recognising that people are at the heart of our industry with focus on improving skills, health, quality of life and fulfilment of employees
- Conservation of natural resources, preservation and restoration of the environment
- Contributing to the development of local and labour-sending communities
- Recognising that metals and minerals are valuable, useful and necessary
- Transformation and growth as key imperatives of the mining industry and nation



PGMs/Gold		
	Human factors/ Just Transition	Research is required in a wide area of topics, ranging from skills development to change management, work organisation, community-related issues and the Just Transition, which is a framework that encompasses a range of social interventions needed to secure jobs and livelihoods when economies are shifting to sustainable production
	Application	Allows stakeholders to develop policies and programmes that will ensure sustainability of the mining industry

PGMs/Gold		
	Modernisation of existing conventional mining operations	Not all mining operations in South Africa will be suitable for mechanisation, thus research is required to ensure continuous improvement of existing conventional operations
	Application	Allows safer, healthier and more productive mining of brownfields to further enable the sustainability of current operations

PGMs/Gold		
	Advanced orebody knowledge	Mechanisation and modernisation of mining requires better knowledge of the orebody ahead of the mining face. The aim of this research area is to find ways of “seeing through the rock” instead of mining blind and thus creating an accurate three-dimensional real-time model that can be used for real-time planning and design work
	Application	Allows for accurate mine design, optimisation and planning

PGMs/Gold		
	Real Time information systems “Internet of Things”	This programme considers the issues surrounding digitisation, and information and communication technology in the mining environment, and how the gold and platinum mines will adopt the “Internet of Things” to reach real-time information collection, monitoring and management
	Application	Allows the PGM and gold industries to improve underground communication and data management

		PGMs	Gold
	Mechanised mining system	Research is required to integrate tested equipment into a working system and to provide real-time monitoring and control (technology transfer is imperative)	A number of components (such as rock handling and support) need to be researched and developed with certain learnings taken from PGMs
	Application	Allows safer, healthier and more productive mining of current reefs, which otherwise become economically sterilised	

		PGMs	Gold
	24/7 mechanised mining system	Rock is extremely hard and the geology is complex	Rock is even harder than PGM-bearing rock, and rock stress is very high, given depths of more than 4km
		Continuous mining machines that cost-effectively cut the ore with reduced dilution have not been developed, rock is extremely hard and the geology is complex, which requires globally leading R&D	
	Application	Allows the PGM industry to mine extensive, deeper orebodies in order to be more productive and thus help sustain the industry	Allows exploitation of lower-grade reefs as well as deep high-grade reefs and high-grade pillar recovery

STRATEGIC FRAMEWORK FOR MODERNISATION

Mining objectives:

- Zero harm for people and the environment
- Investment in more resources for longer
- Job retention

Shared value* in modernising the mining industry:

- Improved mining equipment and systems = improved health, safety and well-being
- Skills development = better pay and improved opportunities for growth and development
- Widespread industrialisation = more jobs associated with mining and beyond
- Sustainability through effective community development and protection of natural resources

**Shared value = simultaneous advancement of social and economic goals*

National objectives:

- Higher growth, employment, exports and government revenue
- Better use of South Africa's mineral wealth
- Improved talent pool of portable skills

Policy enablers:

- Research and development
 - narrow-reef, hard-rock mining equipment and systems
- Manufacturing
 - globally competitive environment
 - employment opportunities in factories and service industries
- Sustainability
 - upskilling of employees and communities/job retention
- Legislative certainty for long-term investment



CONTRIBUTION TO MODERNISATION

A new senior executive position has been created to champion this modernisation throughout the Minerals Council South Africa (Minerals Council). In addition, an innovation team, consisting of senior company representatives, has been established to steer the Minerals Council's efforts.

The Minerals Council has conducted extensive research into mine modernisation and has developed a strategic framework for modernisation to indicate how the mining sector could achieve its objectives while contributing to National Development Plan objectives of higher growth, employment, exports and government revenue.

Three key enablers of modernisation

	RESEARCH AND DEVELOPMENT Massive investment is required with initial focus on narrow-reef, hard-rock mining equipment and systems. Incentives should be provided for companies to invest in R&D. A world-class, collaborative R&D hub is being created through the Minerals Council, various key government departments, universities and research institutions.
	MINING MANUFACTURE The development of a mining manufacturing development programme is underway to facilitate increased levels of local manufacture of mining equipment industrialisation using local labour and a reduced cost of ownership, and optimal mining production.
	SUSTAINABILITY ISSUES A transition road map for modernisation will include sustainability impact assessments of future mining scenarios and accelerated skills development of employees in local communities.

The Minerals Council has identified the products, technologies, people and infrastructure required to mechanise the stoping and development cycle with remotely operated equipment by 2020. Similar requirements have been developed for a 24/7 mechanised mining system that operates without explosives by 2025. Additionally, systems to modernise current conventional mining operations (to make them safer, healthier, more productive and sustainable) have also been identified.

An exciting new area of work that has been initiated is digitisation where appropriate technologies and systems can be developed to keep abreast of international developments in the "Internet of Things" as applicable to the mining industry.

As an outcome of the Mining Phakisa, detailed plans have been developed to accelerate progress in all the building blocks for modernising mining through a partnership between the public and private sectors. The Minerals Council will participate actively in the implementation of these plans. Mining companies have spent over R500 million annually over the past couple of years on innovation. The Minerals Council has advocated that substantive investments be made by government to accelerate these efforts.

This campaign culminated in an allocation in the national budget for R&D in the mining industry (in the extractive phase of the value chain) at levels unprecedented in the past.

None of this work will be sustainable or meaningful without due consideration of the human factors associated with modernisation in mining. An inclusive process of identifying issues and providing win-win solutions for all stakeholders has therefore been initiated through a dedicated programme in this area.

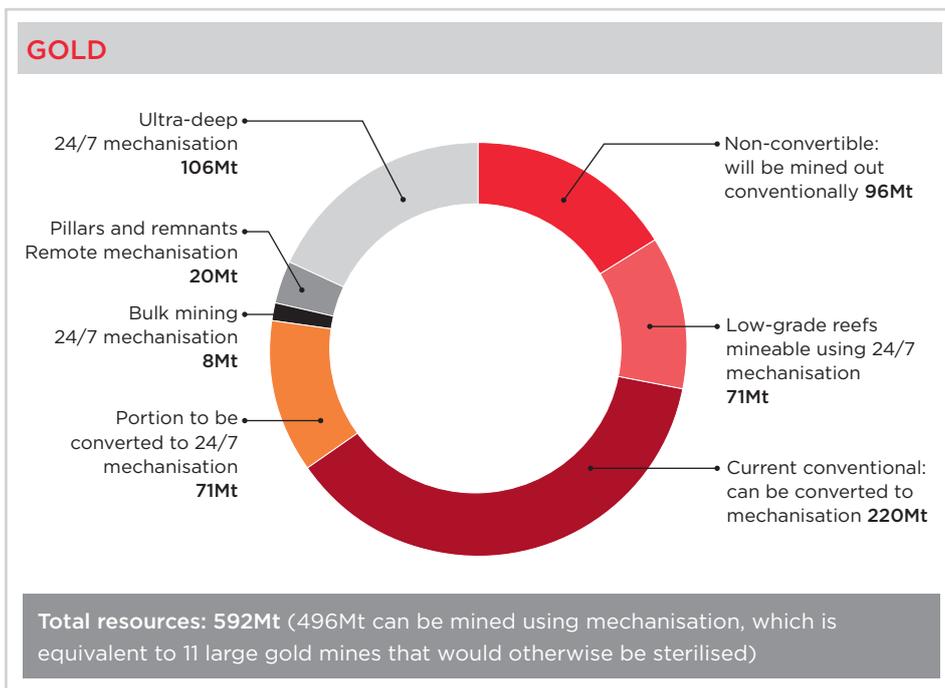
“Modernisation could save around 200,000 jobs by 2030, affecting 2,000,000 dependants.”



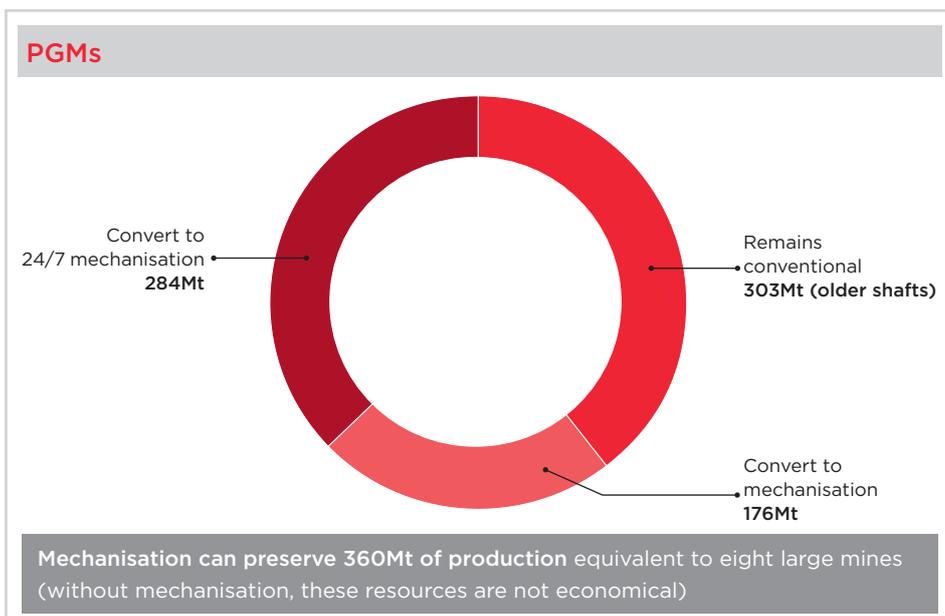
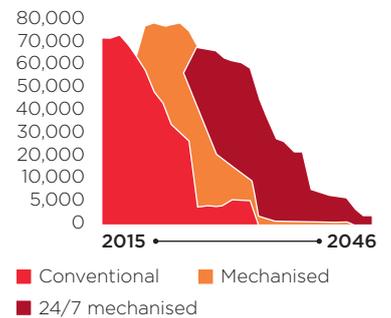
WHAT IS AT STAKE? A CASE STUDY

A study, drawing on the estimates of South Africa's three principal gold companies – AngloGold Ashanti, Harmony and Sibanye – indicates that, for one mine, every 1g/t reduction in the cut-off grade would result in 10Mt of additional ore containing 200t of gold to be mined over the operation's extended life.

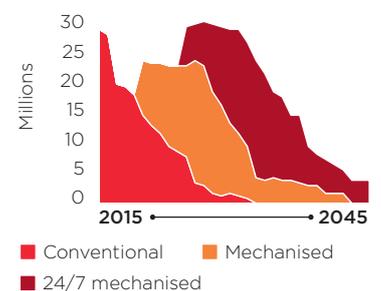
This is an indication of the benefits of using fully mechanised mining techniques, operating 24/7. Extrapolating this across the industry as a whole – to its currently working and dormant mines – profitable gold-mining operations might be expected to continue well beyond the year 2045. Looked at as a whole, with conventional mining, the industry can look forward to a sharp decline in gold production by 2019-20 and for mining to die out almost completely by 2033. The picture changes radically with mechanisation: annual output persists at current levels until at least 2025 and until 2030 or even beyond with 24/7 mechanised operations.



Gold mines TEC



Gold tonnes per year



Similar considerations apply to South Africa's platinum mines although their resources are nowhere near exhaustion as those of the gold mines.

IN CONCLUSION

If this process of modernisation and the manufacture of high-tech, robust and specialised mining equipment is to be achieved, an ad hoc approach cannot be contemplated. The industry, manufacturers, researchers and developers will need to collaborate to the full, sharing their knowledge and skills for common good. The aims are to develop, manufacture and use remotely controlled mobile equipment to break, load and haul ore continuously. Breaking will need to be explosives-free and the equipment must, as far as possible, be self-correcting. However, work on developing continuous miners that satisfy these criteria has yet to begin in earnest.

Learning from the past and, particularly from past mistakes, the R&D process will need to be carefully planned and carried out:

- It must create an environment where everyone (all stakeholders) want it to succeed
- The R&D structure must not slow down progress
- Mechanisation: a 50% reduction in cost per ounce as well as zero-harm operations
- 24/7 mechanisation: a step-change improvement in costs
- A mechanised implementable solution in three to five years
- A workable 24/7 rock-breaking system in 10 to 15 years
- Learn from the past: successes and failures
- Restrict any tendencies to return to conventional mining and allay any resistance to change
- Allow sufficient time for maturity at each phase of R&D

The process cannot be completed overnight so we have to prepare for a staged approach that may differ in the gold and PGM sectors.

The first part of the venture should build on existing knowledge in the gold and PGM sectors. The eventual objectives are systems that combine to deliver 24/7 mechanised operations with costs that permit the exploitation of ores at significantly lower cut-off grades. Extensive and fundamental research is required into mine-worthy, reliable, non-explosive rock breaking in a hard and high-stress rock environment. Targets and milestones will be exacting but reaching for the stars has always motivated humankind.

“Learning from the past and, particularly from past mistakes, the R&D process will need to be carefully planned and carried out.”

MINING HUB

To facilitate and accelerate the process of mining modernisation, a Mining Hub is being set up to co-ordinate R&D, mining equipment manufacture and skills development by mining companies, original equipment manufacturers (OEMs), research entities, skills-development entities and government.

The hub is envisaged as a public-private partnership with a view to “open innovation” so that the costs and rewards of R&D can be divided equitably among contributors.

Open innovation goes beyond drawing on external sources of innovation, such as customers, rival companies and academic institutions. It can integrate adaptations in the use, management and employment of intellectual property by systematically encouraging and exploring a wide range of internal and external sources for opportunities, integration and exploitation through various channels.

The primary objective of the hub is to be a partnership that advances the mining cluster by:

- co-ordinating research and development with initial focus on future underground narrow reef, hard-rock mining systems
- developing South African mining manufacture that supports the country’s narrow-reef, hard-rock mines and promotes export potential of locally manufactured mining equipment
- facilitating skills development for future narrow-reef, hard-rock mining systems

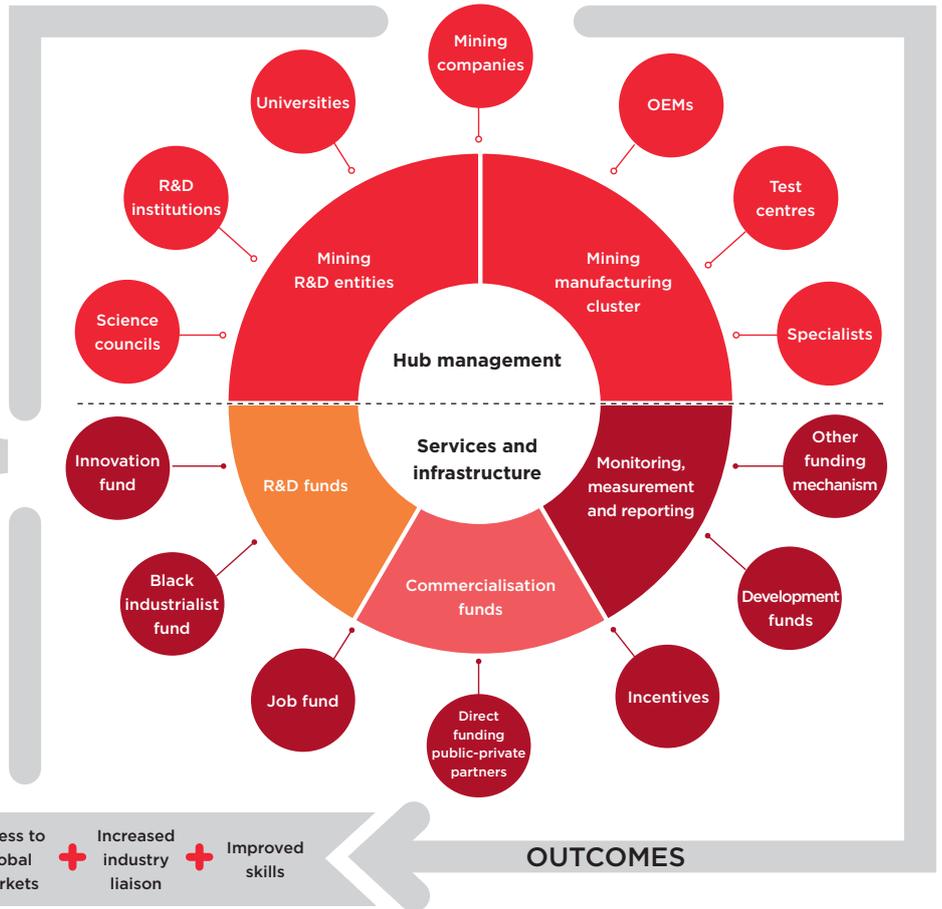
The hub will only co-ordinate (not manage) R&D, manufacturing and skills development. The organisations involved will be selected as “centres of excellence”, which will engage voluntarily, complementing the ideals and objectives of the hub, and not competing counter-productively.

It will be a virtual centre connecting an established network through a central database that monitors the progress of certain pilot projects.

OBJECTIVES OF THE MINING INNOVATION HUB

The primary objective of the Mining Innovation Hub is to be a partnership that advances the mining cluster through:

- 1 Co-ordinating research and development with initial focus on future underground narrow-reef, hard-rock mining systems
- 2 Developing South African mining manufacturing that supports the country's narrow-reef, hard-rock mines and promotes export potential of locally manufactured mining equipment
- 3 Facilitating skills development for future narrow-reef, hard-rock mining systems



Open innovation + Applied R&D + Facilitated local manufacturing = Access to global markets + Increased industry liaison + Improved skills

OUTCOMES



Anglo American Platinum

“A Mining Hub is being set up to co-ordinate R&D, mining equipment manufacture and skills development by mining companies, original equipment manufacturers (OEMs), research entities, skills-development entities and government.”

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