

Putting the shine back into South African mining

A path to competitiveness
and growth

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In brief

The mining value chain is the historic bedrock of South Africa's economy. It directly contributes more than R300 billion to GDP, directly employs more than 450,000 people, and is the economic anchor of many communities around the country.

Unfortunately, much of the news about South African mining in recent years has been negative. Total mining employment has fallen by approximately one tenth in the last 10 years – a net loss of more than 50,000 jobs. Moreover, McKinsey analysis shows that the productivity of South African mining operations for key commodities has declined over the past five years, even as mining companies in other regions have made rapid gains in productivity.

Unless the South African mining industry can improve its cost-competitiveness, even sharper declines in its fortunes could be ahead. McKinsey research finds that 47 percent of South African mining jobs, along with 42 percent of revenues, are in the vulnerable bottom quartile of global cost competitiveness.¹ Global trends, such as the transition to clean energy and a shift in China's economic focus away from infrastructure development to new technologies, could dampen demand for South African mining commodities in the years ahead.

The seriousness of these issues should not be underestimated. Yet our purpose in this paper is not to dwell on the challenges, but to highlight the real potential of the South African mining industry to return to growth. Even in the short term, the industry can achieve global cost-competitiveness if the private and public sectors take concerted action. Mining companies can drive real gains in productivity within the space of a few years if they step up technology adoption and improve key dimensions of organisational health such as employee motivation and the work environment.

In the medium and long term, the prospects for the South African mining sector could be even brighter. The opportunities to rekindle growth and job-creation include localizing the value chain from mining operations, expanding downstream processing for key commodities, and unlocking the potential of the country's rich ore bodies. Amongst others, these include iron ore, manganese and platinum group metals (PGMs), as well as niche commodities such as vanadium and industrial minerals.

Such investments in the mining sector will be critical to accelerate growth in South Africa's broader economy. Given that the life of a mine can extend to 30 years or more, mining is an important driver of long-term investment. It can also be a key source of stimulus for other sectors of the economy, including infrastructure, energy, and transportation. A renewed mining industry can once again be a primary engine of growth, job-creation, and development for South Africa.

¹ This analysis covers four major commodities (gold, platinum group metals, iron ore and export thermal coal) that make up 61 percent of South African mining revenues.

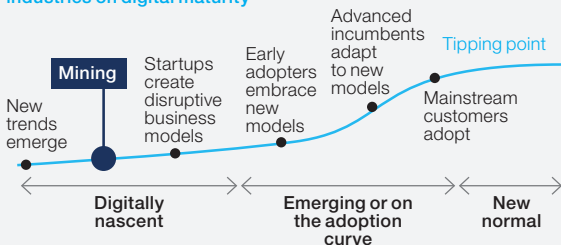
Put the shine back into South African mining

Face up to a challenging context




Global trends

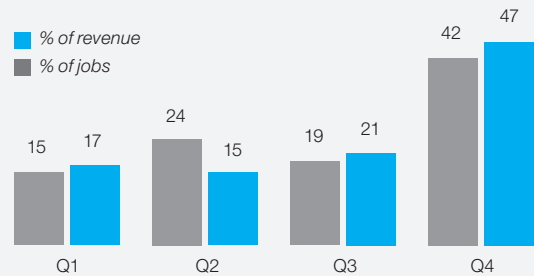
-  **Clean energy scale-up** impacts demand for commodities, e.g., coal and platinum
-  **Changing investor profile** favours new commodity mix
-  **China's changing economic focus** impacts demand for, e.g., iron ore
-  **Technology advances** about to scale – can SA mining keep up?

Mining lags well behind other industries on digital maturity



Local factors

-  **High volatility exposure** – both currency and commodity mix
-  **Declining productivity** – while all other regions are improving
-  **Risky cost position** – 42% of SA mining revenue and 47% of jobs in bottom quartile of global cost-competitiveness



Embrace four paths to competitiveness and growth

1



Unleash a productivity revolution

- Strengthen organisational health
- Enable frontline with technology
- Boost performance through data

Reduce cost position of key commodities by up to **20%**

2



Redefine socio-economic role of mines

- Upskill communities
- Localise value chains
- Stimulate alternative industries

Deliver sustainable growth in mining communities

3



Embrace the energy disruption

- Stimulate adoption of fuel cells
- Invest in vanadium battery storage

Capture a meaningful share of global energy storage markets

4



Unlock high-potential mining assets:

- Untapped reserves of iron ore and manganese in Northern Cape
- Create transparency on SA's resource potential

Grow iron ore and manganese production by up to **2x**

Large-scale impact on revenues, job creation and growth by 2030

Putting the shine back into South African mining

A path to competitiveness and growth

In this paper, we take a sober look at some of the key challenges facing South African mining, and then pivot to the actions that can be taken – both immediately and in the medium term – to tackle those challenges and put the shine back into the industry.

We present this analysis in the context of the revised draft Mining Charter, which has improved regulatory certainty and been welcomed by leaders of the mining sector.² However, our research makes it clear that much more is required to build on this foundation and move the sector back onto a path of sustainable growth.

This paper has been enriched by the insights of leaders across South Africa's mining sector, and beyond, whom we have consulted over the past six months. They include CEOs and senior executives of some of the largest mining companies operating in the country, as well as other senior stakeholders from across South African society.

Between a rock and hard place: the challenges facing South African mining

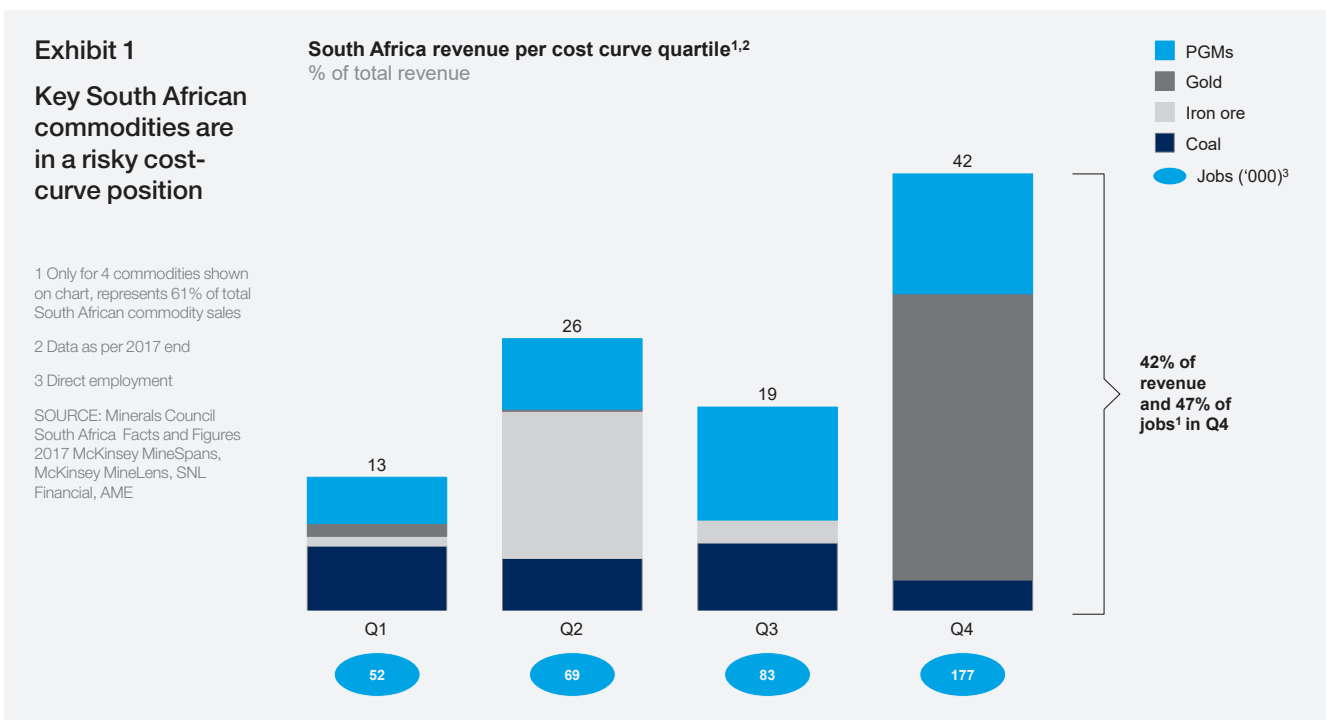
Over the past decade, the South African mining sector has stagnated.

Over the past decade, the South African mining sector has stagnated. In real terms, the sector's value declined by 4 percent between 2007 and 2017. That decline is reflected in jobs numbers, too. Mining employment fell from a peak of 518,000 in 2008 to 464,000 in 2017.

Several contributing factors underlie these troubling numbers. For one thing, the productivity of South Africa's mining industry has fallen steadily, according to the McKinsey MineLens Productivity index, which tracks over 240 mining operations globally. The index shows that the productivity of South African mining operations in base metals, iron ore and platinum declined by 0.3 percent a year between 2013 and 2017. By contrast, the mining sectors in Asia, North America and Oceania improved their productivity by more than 5 percent a year over the same period.

² We refer to the latest version of the Mining Charter, published in September 2018.

A related challenge is the lack of operational and cost-competitiveness of large parts of the South African mining industry. In part that reflects the reality that many of the country's mines are aging, with deposits getting deeper and grades declining. McKinsey's MineSpans database shows that, for platinum group metals (PGMs) and gold, most South African operations are at the least competitive end of the global cost curve. These two commodities are responsible for around two fifths of the country's mining revenues and jobs. For PGMs, gold, iron ore and export coal, we find that 47 percent of South Africa's mining jobs, along with 42 percent of revenues, are in the vulnerable bottom quartile of global cost competitiveness (Exhibit 1). Those four commodities account for three fifths of South Africa's mining revenues.³



A further challenge is that South Africa's mining sector is unusually vulnerable to volatility – both price volatility of the major metals in the country's commodity basket, and currency volatility. Among the leading mining regions of the world, South Africa has the currency with the highest volatility, and a basket of metals with one of the highest levels of price volatility (Exhibit 2, next page).

Moreover, South African mining has faced mounting infrastructure challenges. Electricity costs have increased at double the inflation rate since 2012, while capacity constraints and derailments in the rail network have hampered exports of bulk commodities such as iron ore. Policy perceptions have declined, too. In the Fraser index for mining policy perception, South Africa has fallen to the last decile in the past five years.

³ McKinsey's MineSpans database contains industry cost and supply curves.

Exhibit 2

South Africa has the highest volatility exposure of key mining markets

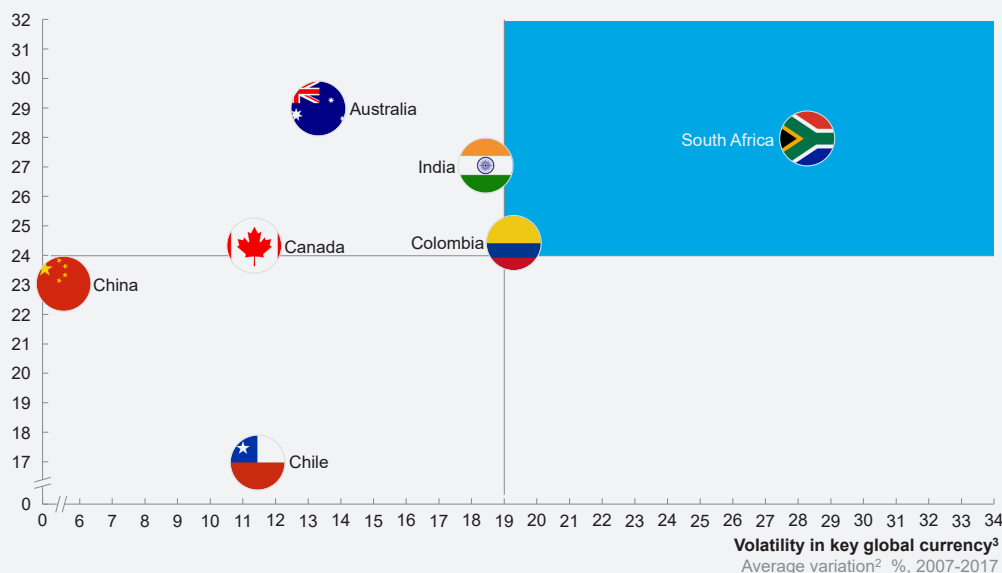
1 Includes Chrome, Coal, Copper, Iron Ore, Lead, Manganese, Diamonds, Palladium, Gold, Platinum and Cobalt

2 Measured by Coefficient of variation (CoV) = (Standard deviation / average) * 100, scale from 0 to 100

3 Relative to USD

SOURCE: IHS Markit, Global Insights, McKinsey MGI

Commodity price volatility for country commodity basket¹
Average variation² %, 2007-2017



Last but not least, the internal challenges faced by South Africa's mining industry are compounded by a flat global growth outlook for the country's main commodities. For the period to 2030, the revenue pool outlook is flat for commodities that make up more than 60 percent of South Africa's mining revenue.

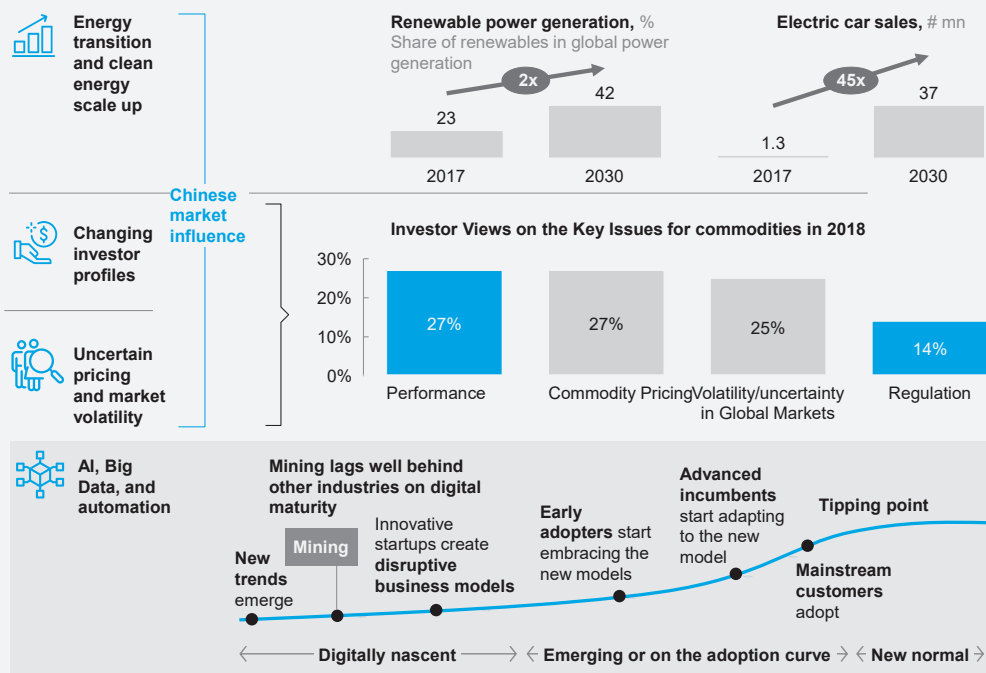
Global trends could put the South African mining industry under further pressure in the years ahead.

Global trends could put the South African mining industry under further pressure in the years ahead (Exhibit 3, next page). These include:

- **Growth in renewable energy sources**, which could impact prices and production of both PGMs and export and local thermal coal. Worldwide, McKinsey Energy Insights forecasts a doubling in renewable power generation by 2030 – along with a 25-fold increase in the production of electric vehicles.
- **China's changing economic focus** as it shifts investment away from infrastructure to new technologies such as battery storage. The result will be lower demand for steel, which could impact South Africa's iron ore exports.
- **Shifts in investor sentiment** characterized by increasing risk-aversion, which is negatively affecting emerging markets. The task of attracting investors is made even tougher by the South Africa's relatively high commodity-price volatility and declining regulatory perception, discussed above, as well as by a lack of appetite for investment in fossil fuels.
- **Disruptive impact of technology**. Although mining today is one of the slower adopters of technology, this will change. The adoption of artificial intelligence (AI), Big Data and automation will likely flatten cost curves and increase pressure for cost-competitiveness across the sector globally. As South Africa's mines are less mechanized than those in many other regions, and a higher proportion of its operations are underground, technology ramp-up will be a more challenging undertaking here.

Exhibit 3 Global disruptions are changing the face of the mining industry

SOURCE: McKinsey Energy Insights' Global Energy Perspective, December 2017, IEA, IHS, Prequin investor outlook: Alternative Assets H1; McKinsey, CSIR, IRP 2016



Where will these shifts leave the South African mining sector? Our projection is that if the current trajectory continues, the factors discussed above could result in 60 percent of South African mining revenue for four primary commodities – PGMs, gold, iron ore and coal – being in the bottom quartile of global cost-competitiveness by 2022. This outcome would see 200,000 South African mining jobs in the bottom quartile of global cost-competitiveness.

Restoring competitiveness and growth in South African mining

The challenges facing South African mining are real, but they can be addressed. All stakeholders can mobilize around a vision of a renewed mining industry that is once again a primary engine of growth, job-creation, and broader economic development for South Africa.

Here we set out a series of proposals for discussion, covering both immediate actions to restore the competitiveness of South African mining and bold interventions to rekindle the long-term growth of the sector and adjacent areas of the economy. The proposals are to:

1. Unleash a productivity revolution in South African mining, including through smart use of new technology and improving employee motivation, the work environment, and other elements of organisational health.
2. Redefine the socio-economic role of mines as catalysts of broader development in the communities in which they operate.
3. Embrace the disruption in global energy markets to realise new sources of potential mining growth – for example, by stimulating adoption of fuel cells and investing in the development of vanadium batteries.

4. Ensure the conditions are in place to unlock South Africa's high-potential mining assets, including its rich, untapped reserves of iron ore and manganese, and niche opportunities in other minerals such as vanadium and industrial minerals.

Unleash a productivity revolution in South African mining

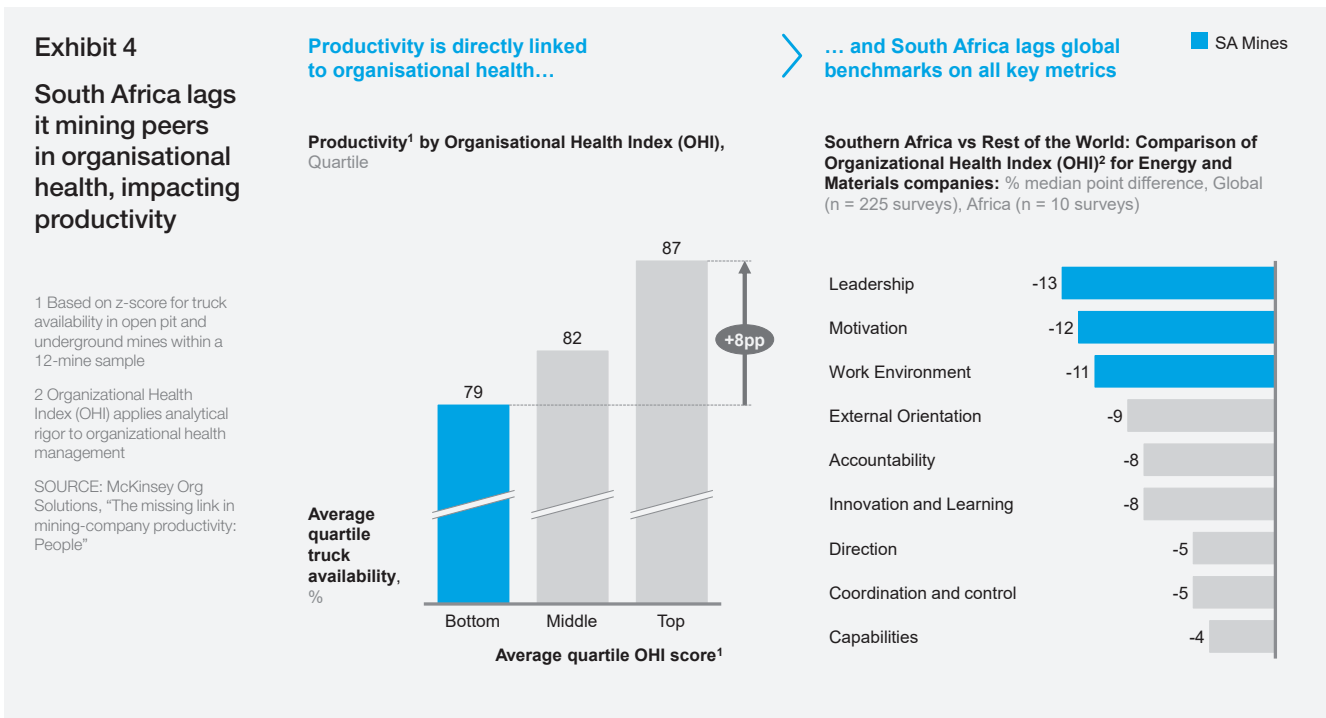
The South African mining industry can take bold, rapid action to raise the productivity of its operations and achieve world-class cost-competitiveness. Mining companies have four big opportunities to unleash a productivity revolution: strengthening organisational health, enabling the frontline with technology, boosting performance through data, and improving operational productivity.

Our analysis suggests that rapid action across all four of these productivity-improvement dimensions could significantly reduce the production costs of South Africa's major mining commodities, and would deliver a major step-up in the cost-competitiveness of South African mining. We estimate that these actions would improve the cost position of mines by up to 20 percent – and increase South African mining revenues by around 15 percent.

Let us consider each of these productivity opportunities in turn.

First, South African mining companies can **improve organisational health** – a key driver of productivity⁴. In many operations, the current work environment does not encourage accountability and ownership among frontline supervisors and workers. South African materials and energy firms (including mining companies) have big gaps in the dimensions of leadership, employee motivation, and the work environment, as measured by McKinsey's Organisational Health Index (Exhibit 4).

Mining companies have four big opportunities to unleash a productivity revolution.



⁴ We define organisational health as the ability to align around a clear vision, strategy, and culture; to execute with excellence; and to renew the organisation's focus over time.

Mining companies already generate swathes of data across their operations, but few use it to generate real value.

To shift this picture, mining companies can create a new organisational model that increases transparency, improves communication, and focuses on leadership development from the early stages of people's careers. That can help create an environment of consultative and supportive leadership – and provide easy access to information such as productivity metrics and company statistics, so enabling employees to understand their role in overall company performance.

Any effort to strengthen organisational health must address the key challenges that employees face in their day-to-day life. For example, one South African mining company found that its employees' personal debt levels stood at 75 percent of net income, and so invested in financial education for its workforce. The most successful organisational-health programmes also include initiatives covering health, safety, and general wellbeing – a key consideration in South Africa, where employees often face long hours and challenging working conditions. For instance, one global mining firm is focusing on improving working environments for miners with cooling suits, better ventilation, and fibre-optic communication tools. Its aim is to improve both worker experience and productivity.

That points to a second big opportunity for mining companies: **to enable the frontline with technology**. They can deploy technologies that improve employee safety, performance management and visibility – particularly underground. For example, companies can provide connected devices, managed by workers, that communicate real-time data on tasks, workplans and progress reports. These will also enable swifter corrective action by management when safety and health issues are identified by the frontline.

One global precious metals mining company issued connected tablets to its underground workforce to foster real-time communication, collaboration and sharing of best practices underground. That greatly improved working conditions and improved productivity by 10 percent. There are many other successful examples of improvements across the industry that harness technology to empower the frontline. In underground mining, for instance, companies have introduced remote operating centres to track and manage the performance of automated drills that are in continuous operation – so reducing downtime and improving both productivity and safety.

To achieve similar gains, South African mining companies will need to overcome challenges such as connectivity in deep underground mines and a lack of digital skills. But with effective design thinking, they can take advantage of technologies that allow more frequent underground connectivity, and tailor their digital solutions to the specific skill levels of each mine. Overall, there is an important opportunity to make digital practices and new ways of working – such as multidisciplinary teams – an integral part of South Africa's mining culture.

Third, there are major opportunities for South African mining companies to **improve performance through data**. They already generate swathes of data across their operations, but few use it to generate real value. The pioneers are showing the way. For example, a South African gold processing plant applied advanced analytics across the key processing steps in a 30-year-old plant – and improved processing by up to 2 percent while reducing costs.

Elsewhere in Africa, a precious metals miner consolidated data from disparate sources into a data lake, then used advanced data analytics to identify improvements it could implement in a few months. It boosted recovery in its plant by 4 percent, even while

There are opportunities to greatly improve predictive maintenance and reduce equipment downtime and cost.

grades were declining. In another example, a North American base metals mining company harnessed advanced analytics to increase the tons produced per day by more than 10 percent, from both throughput and recovery improvements. The company created an artificial intelligence “adviser” that makes recommendations twice a day to optimise settings on controllable variables.

By our analysis, the potential benefits of data-driven insights in South African mining include the following:

- Optimised mine planning to reflect a dynamic medium- and long-term view – with a 4 percent throughput improvement possible.
- Increased fleet productivity through advanced analytics, to improve efficiency and reduce mining costs by up to 3 percent.
- Improved yield recoveries in processing plants – with a potential average yield increase of 4 percent.

Data, along with better organisational health, can also enable a fourth key improvement opportunity: **stepping up operational productivity and asset utilization**. This is an area where South African mining companies currently lag their global peers. For example, a sample from McKinsey Minelens shows that overall equipment effectiveness (OEE) for South African operations is on average 5 percentage points lower than the global industry benchmark, while their unplanned maintenance is nearly 40 percent higher than that of their global peers. That reflects insufficient equipment monitoring in many operations.

There are opportunities to greatly improve predictive maintenance and reduce equipment downtime and cost. Our analysis suggests that, on average, South African mining companies could apply advanced analytics to reduce maintenance costs by 20 percent and increase throughput by 6 percent. There are many other opportunities to use technology to improve productivity – not just in maintenance, mining and processing but also in business support, commercial, procurement and logistics.

We should emphasize that, in the drive for digitization, there is plenty of room for collaboration. For example, companies can create joint digital-mining innovation hubs and incubators, and co-develop infrastructure and technology to lower capital costs and reduce investment risk.

We assessed the overall potential of digital initiatives – both enabling the frontline and harnessing data to improve performance – and found that they could together contribute up to 15 percentage points in improved margins for key South African commodities (Exhibit 5, next page).

Exhibit 5

Digital initiatives could drive significant improvements across all types of South African mines

1 Conv = conventional; UG = underground; Plant = processing plant

2 Augmented Reality

3 Advanced Analytics

SOURCE: Expert interviews; McKinsey Digital opportunity in mining - Top down assessment; Press search

✔ Relevant ✔ Partially applicable ✘ Not applicable

	How digital can improve operations	Examples of impact cases applicable to South African Mines	Relevant for (mining method) ¹ :				Potential impact on margin
			Underground		Open cast	Plant	
			Conv	Mechanized			
A. Enable frontline with technology	Increase worker safety and productivity	Drone technology can shorten surveying time, improve accuracy and enable access to restricted areas	✔	✔	✔	✘	1-3
	Improve performance management and help workers to do their job better	Connected mobile and AR ² devices (e.g. smart helmets) can improve maintenance productivity and performance management by providing real-time access to guides / work plans	✔	✔	✔	✔	
	Improve equipment maintenance and reduce costs	Internet of Things (sensors) can better monitor equipment condition to reduce maintenance demand and consumable cost	✔	✔	✔	✔	
B. Data-driven decision making	Optimize mine planning	AA ³ can optimise mine planning by reflecting dynamic medium /long-term views, linked to processing and logistics capacities	✔	✔	✔	✘	6-12
	Reduce operating costs	Equipment on-board computing data can improve fleet productivity and reduce cost by enabling routing, reducing idle times and fuel consumption	✘	✔	✔	✘	
	Improve plant throughput and yield	Applying AA in the plant can increase throughput and yield by optimizing process parameters	✘	✘	✘	✔	
	Avoid equipment downtime	Applying statistical analysis can reduce down-time and maintenance costs by enabling maintenance only when necessary and optimising scheduling	✔	✔	✔	✔	
Total potential from digital for SA Mining						7-15	

Redefine the socio-economic role of mining organisations

In the short to medium term, mining companies can collaborate with government and civil society stakeholders – and their own employees – to redefine the socio-economic role of mines, and associated processing facilities, as catalysts of broader economic development in the communities in which they operate.

This thrust of action will not only be a key contributor to job-creation and economic development, but makes business sense too. For example, academic research has found an empirical link between the valuation of gold mining companies in North America and their stakeholder relations, with poor stakeholder relations explaining a discounted share price of as much as 50 percent.⁵

The challenge for mining companies in many communities is that mining is the main source of employment. Companies need to reduce dependency on the mine for employment and collaborate to increase the broader set of sustainable job opportunities in the community. Key initiatives can include stimulating the creation of alternative industries such as agriculture and enabling other value-adding activities on their land, beyond mining. In

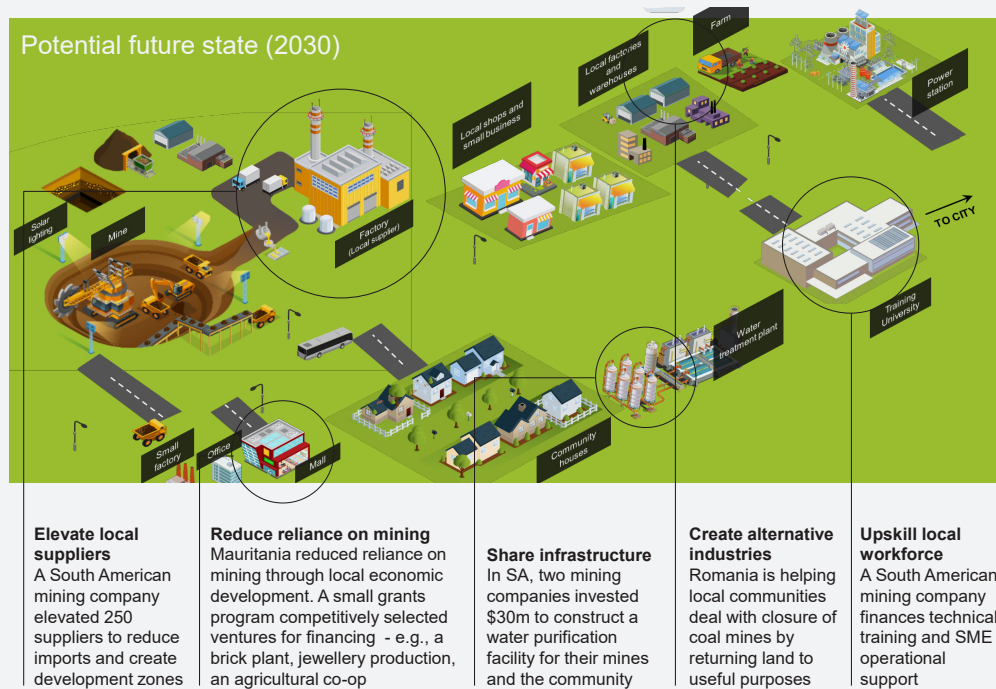
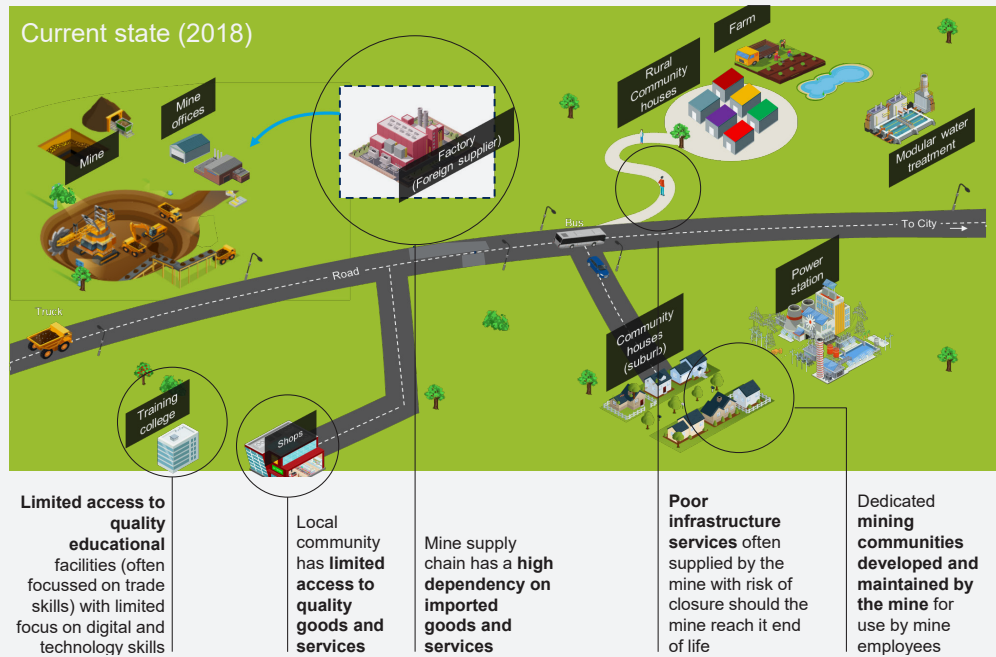
⁵ W. Henisz, S. Dorobantu, L. Nartey, "Spinning Gold: The Financial Returns of Stakeholder Engagement", Strategic Management Journal (2014)

Mauritania, mining companies have helped to stimulate local economic development and reduce dependence on mining operations. Steps taken include financing ventures ranging from a jewelry production facility, to a brick-making plant, to an agricultural co-operative.

Mining companies can also invest in upskilling their local communities, leveraging technology-based learning solutions. There are also important opportunities for mining companies to localize their value-chains around specific mines – making broader socio-economic development integral to their operations. Key steps include elevating local

Exhibit 6

A new socio-economic role is emerging for mining organisations



suppliers by developing sustainable, high-performing contractors beyond simply the period of their contracts.

Taken together, these steps could result in a far-reaching socio-economic transformation in South Africa's mining communities – and in the role that mining companies play in generating economic opportunities in such communities, in partnership with local and national government. Exhibit 6 illustrates what that transformation would look like in action.

Embrace the disruption in global energy markets

In the next five to fifteen years, the South African mining industry has an opportunity to embrace the disruption in global energy markets to realise new sources of mining growth – including by stimulating adoption of fuel cells and investing in the development of vanadium batteries. These could mitigate slowing demand for key commodities.

Consider the example of fuel cells. We expect that internal combustion engines' (ICEs') share of the global fleet will fall from 98 percent today to 70 percent by 2030, while the share of diesel ICEs, which primarily use platinum, will decline from 15 percent to 7 percent of the global fleet over the same period. For South Africa's platinum producers, that spells potential slower demand growth than for other commodities; South African PGM deposits are skewed towards platinum, rather than palladium and rhodium, which have more favourable long-term outlooks.

Fuel cells provide an additional source of growth for platinum – provided the industry and government prioritise the adoption of electric vehicles that use such fuel cells. Fuel-cell-driven electric vehicles (FCEVs) use much greater quantities of platinum, while battery-driven electric vehicles use none at all. Fuel cells can be competitive over long distances on larger vehicles, where there is sufficient hydrogen supply. South Africa needs to work with international partners to help commercialise the technology and inspire adoption in the rest of the world.

For example, the government might set a target of growing the adoption of FCEV buses in South Africa to 10 percent of the total in big cities, and of trucks and light commuter vehicles to 5 percent each. We estimate that attainment of these targets could translate into around 5 percent of current South African sales of platinum. The levers to achieve these targets could include legislating clean-energy use for government fleets as a start; incentivizing manufacturers to produce locally, for example by providing R&D grants; stimulating local FCEV demand by building a refueling network; and providing special economic zones to support manufacturing.

A further opportunity is for South Africa to enter the value chain for vanadium redox flow batteries (VRFBs), a key battery technology that is well-suited to utility-scale energy storage and could replace lithium-ion batteries in many applications. South Africa has rich reserves of vanadium, including the world's largest resource of titaniferous magnetite layers, known for having the highest vanadium grades.

Effective battery storage will be essential as the renewable energy share of power generation ramps up globally, given that power supply from renewable sources is typically dependent on weather conditions and is thus highly variable. Battery-based energy storage can smooth supply and accelerate the ramp-up of renewable energy generation facilities.

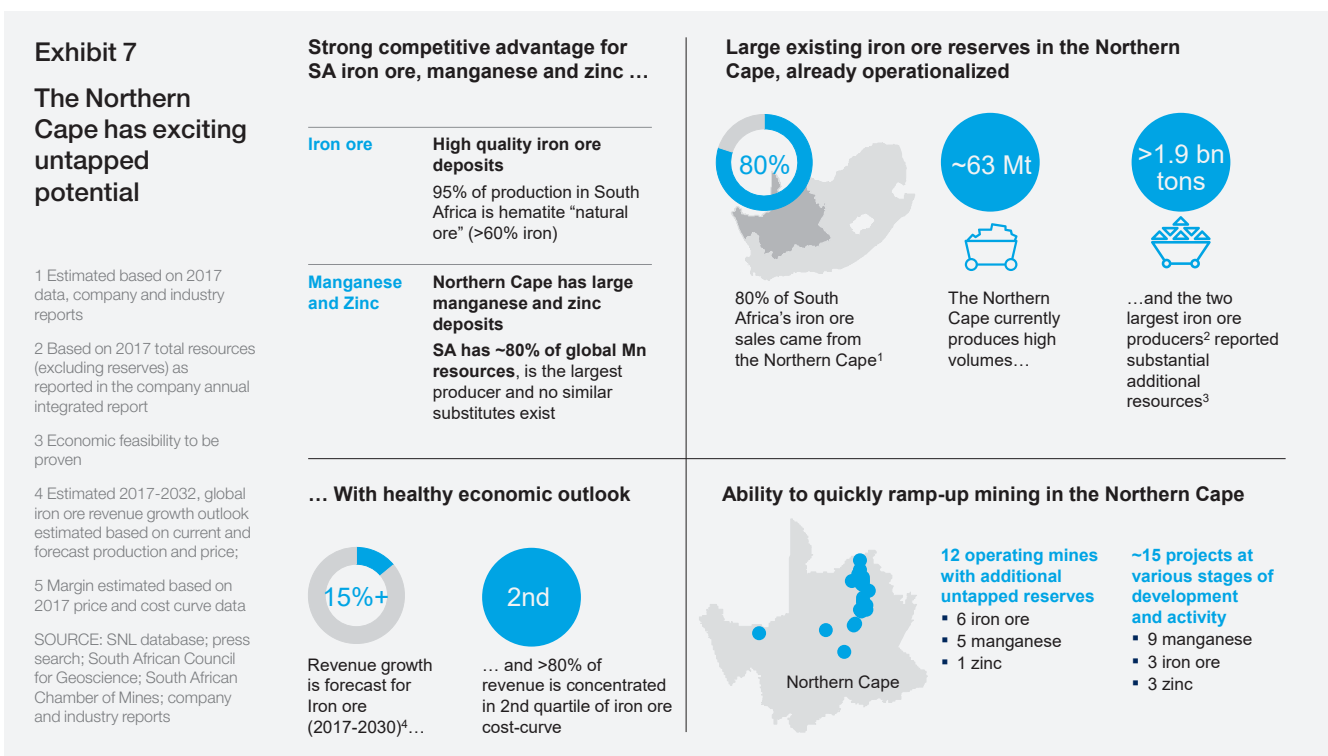
The locational flexibility of large batteries can offer increased resilience for South Africa's power grid. South Africa may not be the biggest consumer of energy in the world, but it can at least make sure it stimulates the commercialization of technologies such as vanadium batteries so that other countries can more easily adopt them.

Again, South Africa's government, in collaboration with industry, can take some clear steps to seize a meaningful part of the global VRFB market leveraging low-cost vanadium deposits. It can demonstrate the efficacy of VRFBs via publicised stress-testing by producers and utilities; develop a standardised plant-building process to optimize capex; and build local electrochemistry and electrical-engineering expertise. We estimate that such initiatives could enable South Africa to capture a good share of the global energy storage market, which is expected to total 300 GWH per annum by 2030 – translating into an industry with annual revenues of more than \$30 billion.

Unlock South Africa's high-potential mining resources

Over the five- to ten-year time horizon, there is a major opportunity for business and government to work together to unlock South Africa's high-potential mining assets, including its rich, untapped reserves of iron ore, manganese and zinc. There are also opportunities to create greater transparency on the country's resource potential by renewing exploration.

A prime example of the potential to unlock mining assets in the Northern Cape, which has high-quality iron ore deposits and large manganese and zinc deposits. In manganese in particular, South Africa has around 80 percent of global high-grade resources, largely in the Northern Cape; no similar substitutes exist. The large existing mining operations across the province are well placed to ramp up production (Exhibit 7).



Stakeholders in the South African mining industry also need to look ahead to the long term. For the mining industry to remain relevant beyond 2030, mining firms will need to undertake large-scale exploration, harnessing the power of new technologies to create transparency on the future potential of key minerals. To enable the long-term investment required to stimulate such exploration, government will need to maintain a stable regulatory regime.



It's time to recast the story of South African mining, which in recent years has been dominated by news about conflict and stagnation. The mining sector has huge potential, given the country's rich reserves, deep reservoir of skills, and solid infrastructure base. That puts South Africa in a strong position to strengthen its reputation as a major mining region of the world. The prize is tremendous in terms of job-creation, greater profitability, and enhanced contribution to the economy.

Mining *can* shine once again as a major engine of growth and development. For that to happen, however, many different pieces of the puzzle will need to come together to ensure the industry can win. Both private- and public-sector stakeholders will need to make a strong commitment to mining's future and take immediate steps both on their own account and by working together. South African mining will also need to face, and adapt to, the large-scale disruptions ahead. The time for action – and true collaboration – is now.

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