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“It appears that the mining industry is poised for greater growth than it’s seen in a decade, but today’s market realities are very different than those of the past. We’re now dealing with geopolitical tensions in the form of trade wars and tariff concerns, as well as looming asset shortages. Rising commodity prices should fuel expansion, but could also result in a return of inflation and the costs that go with it, eventually eating into margins. Disruption and volatility has become the new normal and the pace of change is outpacing our ability to adapt. This makes it imperative for mining companies to clarify how they plan to drive value into the future and how they intend to respond when prices inevitably drop again.”

**Philip Hopwood**

Global Leader – Mining & Metals

Deloitte Touche Tohmatsu Limited



# Solving the value conundrum

We all know that what goes up must come down, but the reverse isn't always true. This explains why the recent resurgence of the mining sector comes as a great relief. With a cyclical recovery in the commodity markets, there has been an uptick in corporate earnings, cash flows, and credit ratings, and a corresponding drop in debt levels. As a result, spending is again on the table, with mining companies considering investing in capital projects and engaging in mergers and acquisitions.

Mining companies now need to determine how to operate in a market characterized by constant disruption, volatility, rising stakeholder demands, a widening talent gap, dwindling access to key inputs such as energy and water, and a Chinese economy growing at under seven percent, rather than 12 percent. In this new

world order, miners will not attract talent, investment, or community support if they only focus on communicating the value that they currently bring to communities – miners will need to go a step further and articulate what they stand for by developing differentiated business models designed to drive long-term value.

Solving this value conundrum mandates them to re-envision their corporate strategy, strengthen their risk management, and find better ways to engage with stakeholders, push the boundaries on their digital transformation, attract truly diverse workforces, and avoid the capital project mistakes of the past. It also requires them to make technology a strategic priority by acknowledging its role as an enabler across every facet of their business.

In *Tracking the trends 2019*, our eleventh annual edition, Deloitte's global mining professionals once again draw on their knowledge and experience to provide mining companies with insights they can leverage in their ongoing pursuit of productivity, capital discipline, strategy development, and sustainable growth. In addition to sharing real-world case studies and best practice examples, our professionals identify potential industry disruptors that may be coming "from left field". As ever, we welcome your input and feedback and remain deeply grateful for your years of support.

*"To thrive into the future, mining companies will need to challenge the status quo—and the only way to do this is by soliciting a diversity of opinions and taking the risk to do things differently. The fourth industrial revolution represents a new era of business that can only be harnessed by leaders who have the courage of their conviction."*

**Glenn Ives**

Americas Mining & Metals Leader  
Deloitte Canada



# Rethinking mining strategy

## Embedding the discipline to deliver measurable value across the cycle

In the not-so-distant past, mining companies, large and small, typically anchored their strategic planning around producing the highest volumes of ore at the lowest possible cost. In the process, the concept of “low cost operations” was recalibrated—becoming a function of prevailing commodity prices rather than a relentless focus on radically shifting the cost base. By now, everyone is familiar with the result of this approach: the drive to build ever-larger

mines in pursuit of superior returns, underpinned by the expectation of constantly-rising commodity prices. This led to large amounts of debt being incurred to fund these projects with significant write-offs.

Although that bubble has long since burst, many mining companies are still grappling with its strategic legacy. In essence, they have not yet sufficiently broadened their strategic outlook to take a range of critical industry shifts into account.

### Hearing voices

Yet the industry is in fact shifting, in ways that many executives never anticipated.

Consider, for instance, the rising voices from a consumer contingent that has historically been silent. Unlike retailers, telecommunications companies, or other consumer-facing businesses, mining companies have never truly answered to the broader “public”. That’s now changing as users of smart phones (which contain more than

62 different metals<sup>1</sup>) and drivers of electric vehicles (EVs)—which rely on increasingly in-demand commodities such as lithium, graphite, cobalt, copper, titanium, aluminum, nickel, and manganese<sup>2</sup>—start questioning whether the metals and minerals in their end-products have been ethically sourced.

Consumers are not the only stakeholders irrevocably altering industry dynamics. Governments and communities have also become more vocal over the years. Both governments and communities have the power to delay or even shut down projects if their needs are not adequately addressed. As a result, corporate social responsibility (CSR) initiatives, which were once approached as mere compliance exercises, are now morphing into stakeholder engagement programs, and social license to operate is becoming a pivotal strategic issue that will either differentiate mining companies or derail them.

### May the best asset win

A similar strategic struggle is taking place at the portfolio level as mining companies attempt to select the “best” assets. The trouble is that, while certain assets look good on paper, their return profile is compromised in practice. A case in point are world class ore bodies located in politically risky geographic regions, where government demands are taking the form of higher royalties, resource taxes, growing requirements for local beneficiation, and even reclassification of key commodities as “strategic”.

An equivalent challenge exists in regions where key inputs, such as energy and water, are scarce. Energy alone can account for up to 30 percent of a mine’s total cash operating costs, when the consumption of grid power, diesel, liquid natural gas (LNG), and compressed natural gas (CNG) are taken into account.<sup>3</sup> At the same time, global capital expenditure on water and wastewater by the mining industry is expected to rise

by 23.5 percent, to US\$1.64 billion by 2019.<sup>4</sup> Hindered by fluctuating energy prices and the difficulty of placing a true value on water, mining companies must continually readjust the relative value of their individual assets—especially where their carbon and water footprints vary from mine to mine and region to region. The strategic implications of this cannot be underplayed.

### Making complex choices

In fact, looking at these factors alone—consumer awareness, social license to operate, geographic risk, and access to input commodities—it becomes clear that mining companies must take an ever-expanding range of issues into account when setting corporate strategy if they hope to create competitive portfolios robust enough to generate value across multiple scenarios. This is especially critical as the industry shifts into a new stage of growth.



### Strategic thinking in action

In a bid to structure asset portfolios geared towards changing market demands, several diversified miners are making bold investment, and divestment, decisions. In March 2018, Rio Tinto completed its exit from coal<sup>5</sup> and has since been looking into bulking up on copper, where high demand is anticipated due to its use by the EV and renewable energy industries.<sup>6</sup> Barrick in its merger with Randgold, has pivoted its portfolio towards tier one assets defined as low cost assets producing more than 500 000 ounces, with more than 10 years of life<sup>7</sup>.

It's time for management teams and boards to put their portfolios to the test by asking some hard questions:

- Are we relentlessly focused on ensuring the cost competitiveness of our assets? To what extent are we embracing digital technologies to control costs?
- Are we the best owners for these particular assets? Can we prove that our portfolio of assets creates more value in our hands than it would in someone else's hands?
- Are we thinking about the future of mining? Can we identify ways to generate returns more quickly or respond with more agility to shifting demand factors?
- Is our portfolio robust enough to withstand the complex array of industry, community, and government risks we face?
- Do we have a response plan and contingent scenarios should the regulatory environment alter?
- Do we have a sufficiently differentiated strategy that describes how we create value for each of our stakeholder groups, such as our investors, customers, communities, and governments? Why would a stakeholder group align with us rather than with a competitor?
- Can we consistently and optimally operate our mines, while adopting necessary local variations? Or does our model result in a different operating model for each of our mines?
- How actionable is our strategy? Have we delineated consistent actions to create value across each operating division? Or, is our strategy confined to the level of aspiration?
- How confident are we in our underlying life of mine models? Are our models static and based on imperfect assumptions? Or, are they sufficiently dynamic to take commodity, grade, and ore body fluctuations into account?
- How are we planning to rehabilitate our assets, and how clearly is this articulated in the market with our stakeholders?



### Strategic thinking in action

Dundee Precious Metals, a Canadian-based gold mining company, acquired a majority interest in MineRP and combined it with Terrative Digital Solutions, a division of Dundee Precious Metals, to create a leading technology provider that is well positioned to further capitalize on rapidly growing demand for digital innovation and integrated technical mining solutions within the mining sector.<sup>8</sup> Goldcorp has partnered with other mining companies to run a series of hackathons called Disrupt Mining, designed to both solve mining challenges and spur the growth of an innovation ecosystem within the mining sector.<sup>9</sup>



### Delivering on the promise

In rethinking mining strategy, it is also important to recall that while value is created at the portfolio or asset configuration level, it is only delivered through rigorous operating and capital discipline. Although exceptions exist, the industry has traditionally lacked the tools and capabilities required to sustainably improve productivity and capital efficiency per unit of output. Without a super cycle to lift performance, value must be found internally.

Notably, some mining companies are taking steps to reposition for the future by revisiting their underlying business models and making new strategic investments. While it remains to be seen whether those moves will be sufficiently far-reaching or radical, one thing is clear: management teams serious about long-term value creation must put strategy at the heart of their board-level conversations.

“When done well, strategic planning cycles consider a range of issues in addition to producing at lowest cost, including the role of individual assets in the portfolio, the path to value creation, the balance between risk and return, and how the company is differentiating itself in the eyes of its stakeholders. These key choices should ultimately drive a mining company’s investment allocation strategy, the partnerships it creates, and the kinds of capabilities it decides to build.”

#### Andrew Swart

Global Mining & Metals Consulting Leader  
Deloitte Canada

# Leading strategies in focus

## **Use data to drive strategy**

Intuition only goes so far in setting strategic priorities. That's why mining companies must rely on data to mitigate unanticipated risks and overcome longstanding biases. From a strategic planning perspective, this means using data to answer causal questions designed to align the management team on the issues it must tackle. Reliance on data to drive strategy also allows companies to shorten the strategic planning cycle and set up feedback loops between geological planning and financial planning, reducing project risks at a time when many miners are looking to expand their capital spend.

## **Put strategy to the stress test**

In an age of disruption, mining companies that fail to expose weaknesses in their

strategy will be at particular risk. To close strategic gaps, companies should stress test their strategy by clarifying their understanding of their most coveted customer segments, their stakeholder value proposition, their key performance metrics, and their risk tolerances. Take some time to answer the questions posed on the previous page to surface any issues that should be considered.

## **Consider a range of scenarios**

Scenario planning, enhanced with artificial intelligence (AI), can give executives a structured way to consider a range of unpredictable futures, equipping them with information they can use to make more flexible strategic choices. This makes it particularly useful to mining companies eager to test the

robustness of their portfolio strategy using AI to consider and monitor multiple market signals. By evaluating multiple scenarios, on both the upside and downside, companies will generally make smarter funding, asset allocation, and investment decisions, particularly if scenario planning is conducted as a continual practice.



## From left field

### **Tokenization**

Tokenization involves converting rights to an asset into a digital token on a blockchain—and it's already making inroads into the mining sector. Goldcorp has begun to use blockchain to make direct sales to dealers and banks<sup>10</sup>, disrupting the downstream value chain. In theory, any asset with ownership (e.g., equities, debt, real estate or commodities) can, and will be tokenized, raising the prospect of a future where complete mines or smaller units are tokenized, enabling them to be traded, and boosting liquidity for miners, far in advance of actual production.

### **Mining as a service**

The past few years have been characterized by traditionally asset-intensive businesses transitioning towards more service-like models (e.g., taxis). Is there a version for mining where companies sell their technical know-how and data as a service rather than owning the underlying assets and infrastructure?



# The frontier of analytics and artificial intelligence

## Moving up the maturity curve

Industry 4.0 and the increased connectivity between the physical and digital worlds, represent opportunities to explore massive amounts of information, do it quickly, and distribute knowledge wherever it needs to go. Yet, as information floods into businesses, data volumes are going through the roof. Every day, the world creates 2.5 quintillion bytes of data<sup>11</sup>, ranging from structured data to more truculent forms of unstructured data from sources such as video, photographs, and text. These shifts are not only driving operational improvements, they are also changing expectations for

adding insight, and raising analytical challenges many organizations are unprepared for, both from a technology and talent perspective.

Mining organizations have started tackling this challenge. They are exploring and investing in analytics and AI in a bid to leverage the data they generate and use it to sharpen planning and decision-making across the mining value chain—to improve safety, increase productivity, reduce cost, or enhance the employee experience.

Yet, despite these improvements, there is still a long way to go.

As mining organizations seek to enhance their analytics and AI maturity, they are asking three key questions:

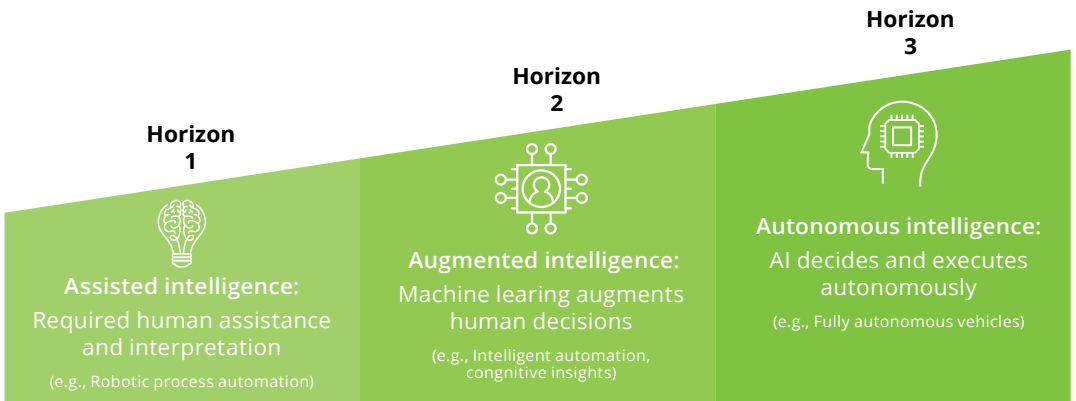
- What are the global trends in other industries, and how are they relevant for us?
- What are the specific use cases in mining, and what value do they deliver?
- Where should we focus our investment, and how do we approach the work?

### Global trends: Three horizons of AI

AI can be simply defined as machines performing tasks that require human intelligence. As we enter an era where intelligent machines work with humans, rather than replacing them, three horizons of AI are emerging (see figure 1).

To date, most organizations are working in Horizon 1, where machine intelligence requires human assistance and interpretation (e.g., robotic process automation). Yet leaders in this space are moving towards Horizon 2, where machine learning is used to augment human decisions and drive cognitive insights.

Figure 1: Three horizons of AI



Source: Deloitte Analytics and Cognitive practice

### But first, some definitions:

- **Artificial intelligence (AI)**—machines performing tasks that require human intelligence, where data interacts with analytic algorithms. Examples: understanding language, decision making, learning and problem solving.
- **Machine learning**—an approach to building AI that involves “training” algorithms with large volumes of data which evolve the algorithm without it needing to be explicitly programmed. Examples: clustering and segmentation.
- **Deep learning**—a machine learning technique where “learning” algorithms use deep neural networks that mimic the brain’s ability to respond to varied stimuli. Examples: image recognition and voice recognition.
- **Natural language processing**—machines that extract or generate meaning and intent from text in a readable, stylistically natural, and grammatically correct form. Examples: translation software and virtual digital assistants.

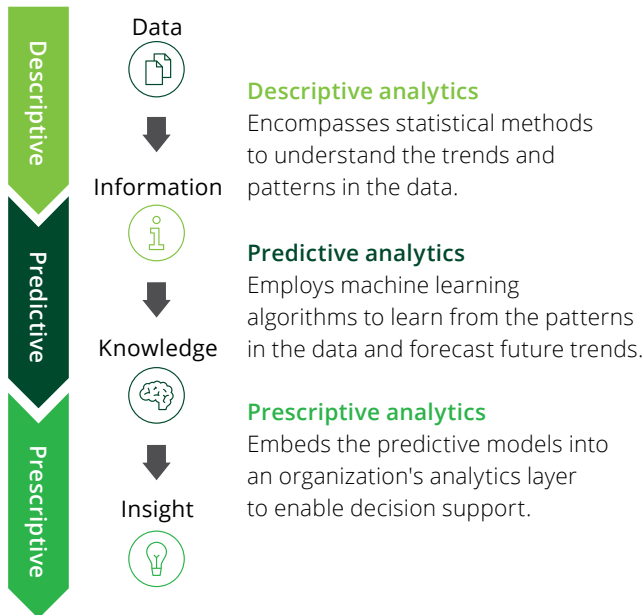
To move up the analytics maturity curve into Horizons 2 and 3, organizations must gain the ability to answer progressively more complex questions. The first is “*what happened?*” and, because it relies on retrospective data analysis, it tends to be the easiest to answer.

The second is “*why did those things happen?*” and allows organizations to identify root causes—for example, to

assess why production fell off during a particular shift, day, or week; why safety incidents spiked; or why environmental performance slipped (was it operator inefficiency? time of day? weather-related? something else?). To answer the “*why*” question, mining companies must be able to integrate multiple and typically, disparate data sets to identify the internal and external levers that influence these outcomes.

Only with this foundation in place can organizations answer the third question: “*what will happen?*” This is the key that empowers organizations to predict variability, mitigate emerging risks, and manage stakeholder expectations. It is also the springboard organizations can use to move from predictive analytics to prescriptive analytics, positioning them to answer the “*how*” question (see figure 2).

**Figure 2: From descriptive to prescriptive analytics**



Source: Deloitte<sup>12</sup>



### **Analytics in action: Mining use cases**

To see what type of value or business outcomes analytics and AI can deliver, and which processes across the value chain they can affect, it's helpful to review several mining-specific use cases.

#### **Mining operations**

##### *Using machine learning to optimize blasting operations*

Processing plants need to be set up to deal with the high variability in the size of fragments created from blasting, and consistent fragment sizes enable more efficient processing. A drill and blast operator used machine learning to identify geologic similarities with previously blasted deposits and the results of those blasting operations, allowing classification of rock mass to be improved to optimize blast design and achieve a more consistent particle size distribution. This greater consistency enabled more efficient plant operation, increased capacity, and reduced operating costs.

##### *Using machine learning and IoT to manage haul truck movements*

A global miner's haul trucks that operate within the pit were often observed queuing at the crusher and shovels. Analysis of truck fleet data revealed an

uneven distribution of haul trucks between shovels. This resulted in longer cycle times and truck bunching. Through the adoption of machine learning and Internet of Things (IoT), truck cycle efficiency was improved, resulting in greater capital utilization and increased annual material movement.

#### **Processing**

##### *Using prescriptive modelling to optimize process plants*

Process plants require constant operational adjustments to maintain steady process performance and quality output given varying inputs. Deloitte has worked with several resource companies to build prescriptive models that optimize a range of process plant activities—including predicting input ore quality, recipe selection, operational set points, and process outputs. Operating plants optimally also leads to reduced downtime and improved equipment utilization. Across various projects, observed results have included reduction in unplanned stoppages, accuracy improvement in input grade prediction, reduced variance in production output and processing time, increased throughput rates and processing yields, and energy cost reductions.

#### **Maintenance**

##### *Using real-time monitoring and machine learning for maintenance planning*

A major miner mounted a camera on its trains to monitor its railway tracks' condition in real time. By uploading these video images to the cloud and using machine learning to analyze this constantly changing data, the company can now generate daily reports on the status of its train tracks, allowing it to both fix immediate issues and schedule preventative maintenance in advance of potential breakdowns.

##### *Using machine learning to predict car dumper faults by anomalous behavior*

At port, the ore unloading process is carried out by car dumpers. For one major mining organization, the clamps represented one of the biggest failure modes of the car dumpers. Hydraulic unit failures were directly associated since the clamps are hydraulically actuated. The low and high pressure bands that increased the probability of mechanical, hydraulic, and electrical failures were identified, allowing models to be built to detect pressure anomalies and generate alerts, reducing unscheduled equipment delays and increasing production capacity.



## **Safety**

### *Using advanced analytics to identify patterns in safety data and gain insights*

Safety observations and reports are typically collected and stored in a semi-structured way and are then archived, while actions based on root case analysis typically only occur after the accident has happened. By applying advanced analytics techniques to a range of data sources, it is possible to process hundreds of thousands of observations and detect relevant patterns, leading to more proactive safety approaches. A major global miner applied this approach to its capital projects—various data sets, including rosters, risk registers, and weather patterns were identified, sourced, and combined, and a range of advanced analytics techniques, including machine learning

and predictive analytics, were then leveraged to identify patterns and gain pertinent insights. The analysis identified the extent to which factors such as the day of the week, hours worked, or weather conditions increased likelihood of a safety incident occurring.

## **Other use cases**

### *Using wearable sensors and machine learning to improve workforce performance*

ThoroughTec Simulation—a global supplier of surface and underground mining, military, and construction simulators—leverages machine learning as part of its workforce performance analysis tool, which uses wearable sensors to analyze mine operator performance in real time and generates insights mine managers can use to identify gaps in operator capabilities and adjust training to meet each

employee's needs<sup>13</sup>.

### *Using machine learning and neuro linguistic programing (NLP) to auto-classify tax deductibles*

A global mining and metals organization is now using analytics to support its income tax compliance processes and enhance its tax governance. The analytics solution automated transaction data extraction, automatically classified transactions for income tax purposes, and presented the analysis in an easy to understand visual format that could be easily interrogated and adjusted. By using machine learning to mimic human cognition, the digital tax solution automatically classifies 97 percent of transactions with a high level of accuracy. The solution does the hard, repetitive work, freeing up time for the tax teams to focus on higher value activities.



### Where to invest and how to work

As mining companies move up the analytics and AI maturity ladder, success will hinge on their capacity to:

- **Think big:** establish a clear vision and strategy, driven by desired business outcomes;
- **Start small:** design and deliver in rapid agile sprints, starting with a minimum viable product or solution; and
- **Scale fast:** rapidly scale up successful projects that have demonstrated value (and kill-off those that don't), and focus on embedding the change operationally.

Another important consideration for all organizations embarking on digital transformation is the “talent crunch”. We are observing talent models increasingly tilting toward data science and business partnering skills. As companies seek to upgrade their workforces in all areas, they are placing a premium on people who have relationship and analytical skills, combined with an understanding of the business. Many organizations do not have the right people in place to make this shift. Training and development can help, but the need to recruit for

new skills is taking on urgency, and new approaches will be needed in talent attraction and development, and organizational planning.

After selecting the right use cases, and considering the talent issues, there are several strategies described below which will help organizations “think big, start small and scale fast”. The key is to get on with solving real problems and delivering value as quickly as possible, while keeping the big picture in mind.

“Experience shows that the majority of early analytics use cases have been targeted point solutions, which deliver value in only one part of the value chain or at only one operation. Increasing analytics maturity requires greater integration of data from multiple sources, and delivery of end-to-end planning and decision-making solutions that span multiple processes and operations.”

**Paul Klein**  
Consulting Partner  
Deloitte Australia

# Leading strategies in focus

## **Integrate and evolve**

Increasing analytics maturity requires greater integration of data from multiple sources, and delivery of end-to-end planning and decision-making solutions that span multiple processes and operations. This ultimately requires a data and infrastructure platform with the ability to capture consistently sourced and reliable data, the responsiveness to support a complex network of data flows—including internal and external data available in both structured and unstructured formats—and the scalability to enable deep-dive analytics across large data sets, while still evolving in tandem with business needs. Although it is necessary to have a big picture to work towards, it is better to build the foundational data and infrastructure platforms in an evolutionary way while delivering specific use cases, rather than trying to build it all up-front. Legacy attempts to do the latter which can take too long to deliver value.

## **Leverage next-gen ERP systems**

The big picture referred to above should also take into account the current state and future migration path of back-office systems, including the move towards cloud-based ERP solutions and in-memory computing.

The latest generation of these ERP systems now offer increased reporting and analytics capabilities, and the integration of ERP and non-ERP data will be a critical consideration in the delivery of more mature analytics solutions.

## **Embed the change**

The successful adoption of more mature analytics capabilities requires top-down leadership support if changes are to be embedded in operational processes. Equally important is buy-in from operational and functional people whose roles will be affected—they need to be sufficiently involved and engaged in the delivery of the solution to understand and believe in the benefits of the change.

## **Create a virtuous circle**

To build analytics maturity, it makes sense to roll out analytics initiatives in a way that develops capabilities within the organization. Use cases can be selected to leverage and enhance internal skillsets—supplemented by specialist external expertise where necessary—so that, over time, the company gains the capacity to execute on progressively wider-ranging and more complex initiatives.

The page features several light green gear icons of varying sizes scattered in the background. A large, hollow gear shape is centered on the page, containing the main text.

## From left field

Imagine a future where mining companies can identify ore bodies in greenfield and/or remote areas without access to pre-existing geological data. Thanks to the power of AI, that future is here. EARTH AI uses machine learning to analyze geophysical data to identify unexplored mineralization opportunities in Australia. Since April 2018, it has discovered 18 new greenfield prospects with significant copper, zinc, lead, and vanadium mineralization.<sup>14</sup>



# Managing risk in the digital era

## Exploring a new approach to controls and risk management

Risk. It's rare that four letters can embody a spectrum of such unpredictable and sudden shifts. Yet these are precisely the conditions that prevail in today's mining industry, where the current risk landscape is characterized by mounting tariffs and sanctions, potential trade wars, cyber threats arising from unexpected attack vectors such as equipment sensors, uncertain tax and royalty regimes, rising input costs, heightened scrutiny from the investment community, environmental disasters and infrastructure breakdowns that can result in mine shutdowns, public protest spurred by viral

social media campaigns, and the geopolitical perils that come with operating in less stable regions.

In just a rough sampling, recent months have seen the U.S. impose tariffs on US\$200 billion of Chinese goods, including bismuth, titanium, and cobalt;<sup>15</sup> increased royalties imposed on copper, gold, and cobalt, which has been declared a strategic metal by the Democratic Republic of Congo;<sup>16</sup> the introduction of two new laws in Tanzania asserting the government's "permanent sovereignty" over its natural resources;<sup>17</sup> and audits by

the Zambian government of the past six years of mining company financial statements, resulting in First Quantum Minerals receiving a controversial US\$7.9 billion tax bill.<sup>18</sup>

The velocity of risk further complicates matters. An interconnected global economy means risks are rarely confined to national borders, mandating a rapid and coordinated response.

Despite this, many mining companies continue to address risk as a tractable concern, using risk registers to rank risks

from high to medium to low, taking a compliance-based approach to risk assessment, using cyclical three-year plans to identify trouble spots, and relegating internal audit to a mere policing function responsible for risk assurance rather than the anticipation of emerging risks.

The danger here is obvious. Risks unidentified are risks unmanaged, leaving exposures that could compromise a company's financial performance, health and safety record, and social license to operate. It doesn't help that many risks were inconceivable just a few short years ago. For example, a mining company that decides to enhance transparency by providing real-time results on its emissions data might find itself at risk of having that data manipulated by malicious parties. Similarly, the prospect that automated equipment, from vehicles to air vents, could be hacked raises risks that are all too real.

### **A new value proposition**

To stem this tide, it's time for mining companies to take their cue from organizations that take a more holistic view of risk. Increasingly, these leaders are moving towards the next generation of internal audit, Internal Audit 3.0.

As with any useful new release of an operating system or application, Internal Audit 3.0 offers new features and functionality, and retains the best of past versions. Internal Audit 1.0 was marked by the founding of the Institute of Internal Auditors in 1941. Internal Audit 2.0 grew from the impact of Sarbanes Oxley on the accounting profession.

Internal Audit 3.0 is being shaped by a range of other drivers, including the speed at which organizations are now expected to evolve and innovate as we enter the fourth industrial revolution. This greater pressure to create and deliver value compels internal audit to adopt a new vision of its role, one centered not only on delivering assurance and advice, but also on anticipating risks and helping the business craft preventative responses.

At the heart of this next generation of internal audit and risk, lies analytics and a range of AI and cognitive tools that are now available and accessible to mining companies.

Rather than use people to perform audits on a rotational basis, internal audit firms can now use digital assets, such as analytics, robotic process automation (RPA), and AI. Core assurance can additionally be automated and non-conformance identified where controls can be flagged in real time.

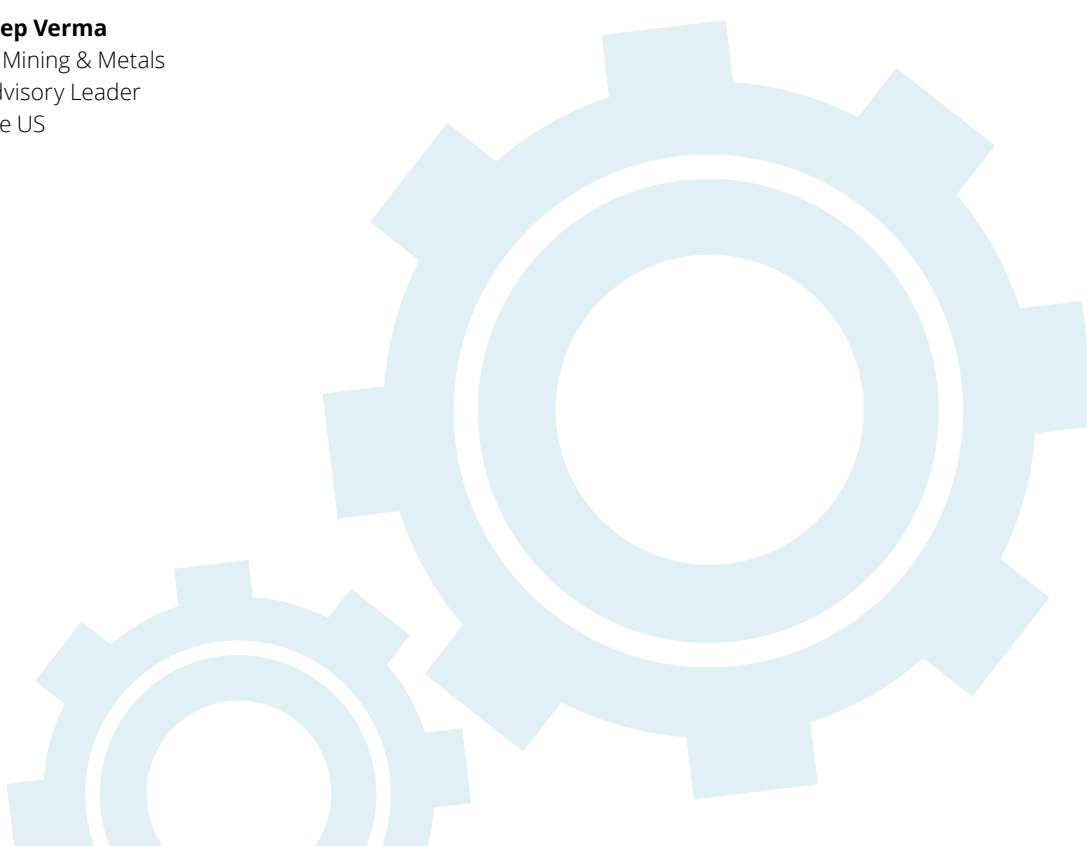
With unparalleled access to enterprise-wide information and growing capabilities to use external data, management and boards should use these tools to anticipate risks, moving firms from a backward-looking view that reports on what went wrong to a forward-looking function that prompts awareness of what could go wrong, and what to do about it, before it happens.

The complexity of geographic, regulatory, environmental, operational and compliance risks have never been greater. While temptation on the part of management is to add additional cost to their overhead structures, it is important that the digital trend that is taking hold in the operations of mines is extended into the back-office, and the use of analytical and AI tools are embraced to re-invent how mining companies manage risk.

Ultimately, this approach should help mining companies address risk at an enterprise-wide level, rather than assessing isolated risks at the functional or mine site level, and allows companies to develop appropriate controls to both mitigate and manage the expanding array of risks they face.

**“In today’s broadened risk landscape, where traditional assurances around risk are no longer effective, boards, investors, and communities expect mining companies to have a forward-looking view on risk. Rather than simply defining risks, companies should revisit their approach to risk management to ensure that all lines of defense are empowered to manage risk on their behalf.”**

**Sandeep Verma**  
Global Mining & Metals  
Risk Advisory Leader  
Deloitte US



# Leading strategies in focus

## See the future

Leading organizations increasingly rely on risk sensing platforms to monitor risk indicators based on internal and/or external data. For example, many organizations monitor social media for customer sentiment and reputational risks, or newsfeeds and regulatory filings, and apply analytics to identify themes and trends. Industrial companies monitor central bank policies to anticipate interest rate movements. Others look for financial, operational, or cyber trends. Risk sensing, which combines advanced analytics with human judgment, provides a panoramic view of risk, extending well beyond traditional risk registers of identified risks. It focuses on emerging, often unknown, risks to enable anticipation of issues, as well as real-time and continuous risk assessment.

## Reduce the level of unknown unknowns

Risk learning, or cognitive risk anticipation, applies analytics to risk events to tease out causal relationships. If a risk event occurs, analysts can examine what else occurred before, during, and after the event. Over time, by applying pattern recognition and root cause analysis to a growing database of events and factors, the organization can isolate correlations, sequences of events, and

causes and effects. This allows management to take proactive steps to avoid or mitigate risk events, while positioning internal audit to conduct proactive assurance work related to those steps.

## Raise accountability

One way to link risk management to real-world controls is by making management and the board directly accountable for risk assessment. This could take the form of asking management for a signed declaration, similar to financial statement certifications, providing assurance that appropriate systems and controls are in place to mitigate specified risks. While this represents a major shift in how executives and the board think about risk management, it makes the process real in a way that mere reliance on an enterprise risk management (ERM) system does not.

## Skill up

To effect true change, internal audit functions need, what we call 'purple people' —people with a mix of business and technology skills that allow them to understand new cognitive technologies in a business context. They may also need access to polymaths, experts who can ask the right questions, understand stakeholder needs, and embrace new ways to provide assurance.

Organizations struggling to attract this caliber of talent may want to borrow internal audit staff, source subject matter experts for specific engagements, or even co-source or fully outsource their internal audit function.

## Go outside

Risk registers are often developed at the operating level, which raises risks of its own. Often, operators either do not or cannot provide an objective view of prevailing risks, due to ingrained biases or the role they personally played in adopting less-than-effective controls. To overcome this challenge, consider asking external auditors or risk advisors to conduct an independent risk assessment.

## Learn to share

Within mining organizations, risk management expertise tends to be dispersed across functions and geographic locations. To strengthen their risk management culture and better mitigate common risks, companies should aim to share lessons learned and leading practices across mine sites. This cultural shift is key.



# Digitizing the supply chain

## Why innovation requires integration

Conversations around the fourth industrial revolution, or Industry 4.0, revolve around the ways in which physical and digital technologies—such as analytics, AI, cognitive technologies, robotics, cloud computing, and the IoT—are combining to create digital enterprises that are both interconnected and capable of more informed decision-making. To harness the power of this shift, however, organizations must determine precisely where to invest to maximize their returns. One area ripe for transformation is the mining supply chain.

### **A haphazard approach**

Unlike industries such as manufacturing and automotive, the mining sector still lags in its efforts to digitize the supply chain. Despite the challenges associated with accessing critical materials and equipment, particularly in remote locations, mining companies rarely approach their mine site planning, asset maintenance, and materials processing and transport in an integrated fashion.

Although many companies have begun digitizing discrete pieces of equipment—such

as their trucks or trains—they have not extended these efforts across the entire supply chain, from pit to port. As a result, the data they generate from the technology they have installed exists in a vacuum—hampering their capacity to generate true insights that could otherwise enable them to reduce inventory costs through just-in-time procurement, enhance asset utilization rates, and improve their production outcomes by making their EPC relationships more dynamic and responsive.



In essence, a supply chain paradox exists. Although most mining executives agree that the supply chain is a top priority for digital transformation investments, supply chain leaders are generally not consulted when it comes to making decisions about those investments. As a result, supply chain improvements remain incremental rather than delivering innovations designed to optimize mining operations.

**The digital supply network**

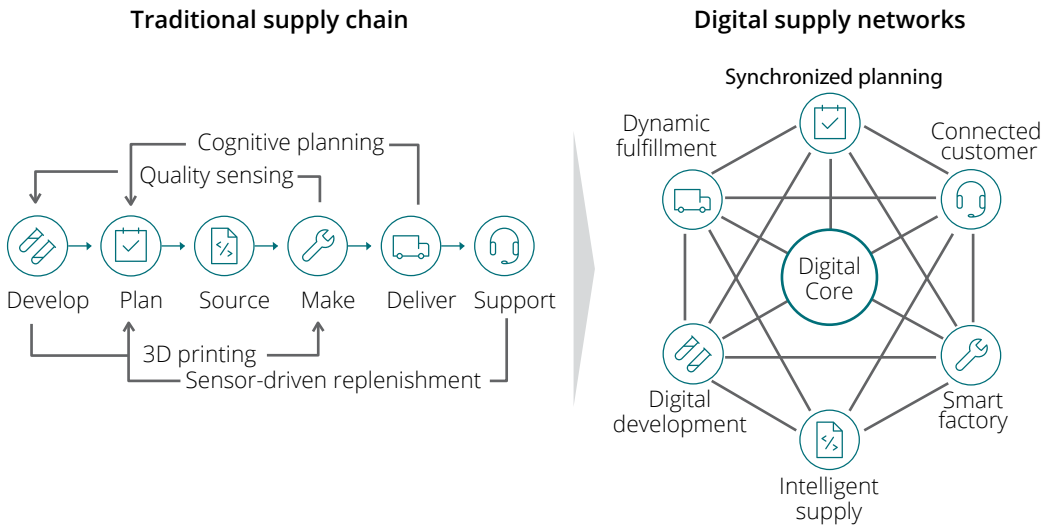
To create a more interconnected and responsive supply chain, mining companies need to

stop thinking in linear terms and imagine instead a circular system that we call the digital supply network (DSN). The distinguishing characteristic of a DSN is that it is capable of integrating information from a wide variety of sources (e.g., IT/OT sensors, GPS data, wearables, core operations data, partnership data) to predict specific outcomes—such as equipment wear and tear, shifting demand signals, operator behavior patterns, or inventory levels.

Armed with this data, companies can make more informed

decisions about how to streamline their supply chains by investing in targeted physical technologies like robotics, drones, additive manufacturing, and autonomous vehicles. It's a virtuous loop, one that employs real-time data to accelerate decision-making, enhance transparency, and enable collaboration across the entire supply network.

**Figure 3: Shift from traditional supply chain to digital supply network**



Source: Deloitte analysis

As figure 3 shows, digital is at the core of the interconnected lattice of the DSN model. There is potential for interactions from each node to every other point of the network, making communication multidirectional. For example, drone video

monitoring of remote work sites enables site optimization analytics to detect emerging issues, while on-site 3D printers rapidly replace needed parts to reduce downtime.



### The digital supply network in action

To reduce costs and enhance supply chain agility, EasyJet employs augmented reality smart glasses to enable two-way communication between its network of remote maintenance technicians and its central engineering team. Virtual step-by-step walkthroughs in real time enable technicians to effectively perform complex maintenance tasks and reduce downtime. EasyJet also uses drones to perform efficient and immediate visual safety inspections of the exteriors of its plane bodies, reducing the time the plane is out of service, how much hangar space is required, and the amount of inspection labor.<sup>19</sup>

### The last mile

To enable this multidirectional communication, the flow of information across the nodes of the supply network must occur through an iterative series of three steps, known as the physical-digital-physical (PDP) loop. In a nutshell, here's how it works:

First, information is captured in the physical world—through ERP or CRM systems, or even email—to create a digital record. Next, that data is analyzed to draw meaningful insights. Finally, those insights are used to spur action in the physical world. The result is a more flexible system

capable of adapting to and learning from changes to the environment (see figure 4).

Although most mining companies have the first stage of the PDP loop in place, and many have the second, far fewer are yet able to harness the last, most important stage—the ability to act on the data they have analyzed. In fact, some research shows that miners may use less than one percent of the data they collect from their equipment.<sup>20</sup>

Before the industry can use the supply network to fuel growth, rather than merely driving

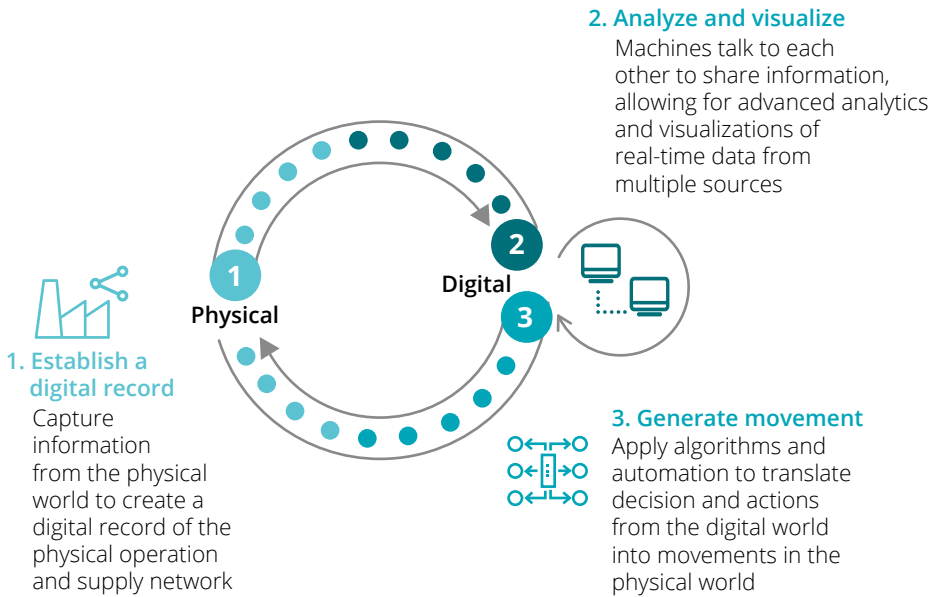
incremental improvements, a cultural shift must take place—one that empowers executives to make decisions by relying on data outputs rather than on gut experience. This is ultimately the nirvana of the DSN—the ability to leverage advanced algorithms, AI, and machine learning to turn data into insights that allow companies to reduce their capital expenditures, respond to changing project requirements on the fly, and optimize mine planning to integrate real-time changes.

“The mining sector is at the earliest stages of building a digital supply network—which is both a risk and an opportunity. Those organizations that crack the code around fully interlinking their supply chains can do more than break down operational silos. They can also gain the end-to-end visibility they need to enhance their asset utilization, operational efficiency, and productivity—realizing hard dollar savings as a result.”

### Kevin Xu

Mining & Metals Leader  
Deloitte China

Figure 4: The physical-digital-physical loop



Source: Center for integrated research

| Deloitte insights [deloitte.com/insights](https://deloitte.com/insights)



### The digital supply network in action

To gain an integrated view of its entire operation, Australian iron ore miner Roy Hill implemented an IoT-based platform that streamlines its demand chain planning, inventory tracking, quality management, and capacity simulation. By interconnecting its systems across pit, port, and rail, the company has optimized the flow of parts, contractors, and equipment to maximize availability and improve supply chain performance. It also centralized its maintenance planning and engineering services, and brought all its supply system functions together—vastly enhancing collaboration across its extended enterprise.<sup>21</sup>

# Leading strategies in focus

## **Think big**

Often the first step in transforming a supply chain into a DSN is understanding what drives the need to differentiate. This positions organizations to examine the supply chain applications best suited to their business objectives. The key here is to understand the art of the possible before determining how to build the digital maturity required to reach the organization's goals. It can be useful in this regard to build a digital committee, foundry, or factory responsible for defining the organization's data acquisition approach, core platform, and project milestones.

## **Start small**

To make the transition to DSNs manageable and realistic, it often makes sense to start with smaller stakes, where strategies can be tested and refined with relatively fewer consequences. Selecting projects at the "edges" of the organization can provide greater latitude for building DSN capabilities.

## **Close the PDP loop**

The true power of a DSN comes from its capacity to integrate data generated across all areas of the enterprise—from geographically dispersed mine sites to back office functions to the executive suite. Although this may require

additional investment in digital technologies, many companies can likely leverage the tools already at their disposal—such as IoT data collection, ERP systems, social media listening, and predictive modeling. To maximize their return on investment, organizations may want to first build on these existing capabilities so they can identify areas where targeted investments are truly required.





# Driving sustainable shared social outcomes

## Finding value beyond compliance

For several years, we have featured variants of this trend in this publication. In the past, we have highlighted the need for companies to put their Corporate Social Responsibility (CSR) efforts at the heart of their strategy, we raised the need for different engagement models and we have spoken about the holistic nature of the resources that need to be optimized in relation to the community. This year we focus on the need for the creation of shared value, a concept that has been around for a while, but one which has yet to be embraced by the wider industry.

Mining companies have long recognized the imperative of earning a social license to operate. To gain the trust of local communities in regions around the world, companies have invested billions of dollars building local schools, hospitals, and infrastructure, and supporting communities through local procurement and employment.

Yet recent years have amply demonstrated that these investments frequently fail to yield their desired results. In many regions across both developed and developing

economies, local communities remain vehemently opposed to mining activities, and continue to demonstrate their opposition through refusals to negotiate, lockouts, protests, and outright violence.

Clearly, there is a disconnect here, which may stem from miners' historical approach to corporate social responsibility. The issue? Until recently, mining company social spend has been seen as a cost of compliance, rather than a way to deliver measurable and sustainable benefits to host countries and communities.

If mining companies hope to drive different social outcomes, that dynamic has to change.

### **The rise of the social enterprise**

This profound shift is not confined to the mining sector. Today, organizations across industries are being assessed on metrics that extend far beyond financial performance. Rather, they are being judged on the basis of their relationships with their workers, customers, communities, and regulators—as well as their impact on society at large—transforming them from business enterprises into social enterprises.

A social enterprise is an organization whose mission combines revenue growth and profit-making with the need to respect and support its environment and stakeholder network. This may sound like altruism, but it's not. Mining companies that fail to live up to these expectations not only stand to lose their social

license to operate, but expose themselves to financial risks as well. In fact, operating delays caused by social conflicts can cost mining companies more than US\$20 million per week.<sup>22</sup> Conversely, mining companies that enter community benefits agreements—in which communities consent to new investments in return for tangible benefits, such as revenue sharing—can see their market value double under certain conditions.<sup>23</sup>

### **Common ground**

Yet finding value beyond compliance is no easy task. It requires miners to listen more closely to their constituents to determine what stakeholders truly want, and then to shift their operational processes in response. Rather than trying to “buy” a social license to operate through community investments, for instance, mining companies may need to integrate local manufacturers into their supply chains or alter their water use policies.

They will also need to take steps to help sustain community value beyond a mine's closure. The approaches adopted to make this happen will necessarily vary from region to region. Some best practices include educating local communities on health-related issues so they can reduce the incidence of preventable illness and disease; providing communities with financial training to build viable businesses; leveraging existing infrastructure to create new economic activity and reskilling local workers in alternative industries, such as agricultural production, which can help them thrive once local mines shut down.



### **Shared value in action**

Acknowledging that mining companies are frequently perceived by communities as being part of the problem, not part of the solution, Rio Tinto recently announced plans to reshape its image. Through a series of local campaigns, the company is working to tell a more compelling narrative about its contribution to society in recognition of the fact that miners cannot secure a future without strong community support.<sup>24</sup> The company is already taking action to stand by this commitment, becoming the first major mining company to support the public disclosure by host governments of their mining contracts.<sup>25</sup>

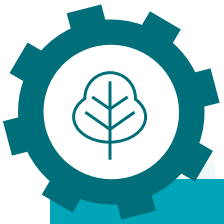
### A new age of collaboration

To deliver on the social breadth of these programs, mining companies cannot work in isolation. Instead, they should look for opportunities to collaborate by pooling resources with other companies working in the region.

They should also aim to strengthen their relationships with local governments and regulatory bodies. This may see them change their traditional

interactions with government.

For instance, rather than lobbying local governments for favorable tax treatment, mining companies may want to look at the tax incentives governments already offer to stimulate local activities—such as industrialization, job creation, manufacturing, and agriculture—and align their investments to help meet these public sector priorities, giving them an alternative route to spur lasting social value.



### Shared value in action

Deloitte conducted a study of six manganese and four iron ore mines in the Northern Cape of South Africa, a region that struggles with high levels of youth unemployment and low levels of education. While the mining companies were eager to address the dire socio-economic conditions across the four municipalities where they work, the effort was too great for a single-company mandate. Through collaboration, however, the companies have gained the scale required to improve delivery success and increase the impact of their programs, which has enabled them to start making strides towards improving quality of life across the region by contributing to local job creation and social upliftment.<sup>26</sup>



### The litmus test

Although these changing expectations put greater pressure on mining companies to address social problems, they also create an unprecedented opportunity to fill the void on issues from income inequality to healthcare. Leading organizations are already rising to the task. A case in point is the not-for-profit organization started by Amazon, Berkshire Hathaway, and JPMorgan Chase

to lower healthcare costs for the more than one million people who receive health insurance from the three companies.<sup>27</sup>

Beyond driving sustainable social outcomes, and boosting financial outcomes in the process, this approach can also help mining companies positively answer a question that is becoming more vital: when we look in the mirror held up by society, do we like what we see?

“By taking the time to understand local community concerns and social objectives, mining companies have a unique opportunity to devise uncommon solutions to intransigent problems. This positions them to form true collaborative partnerships, change negative perceptions about the industry, avert social conflict, and play a more proactive role in helping local governments deliver on their developmental outcomes.”

### Andrew Lane

Mining & Metals Leader  
Deloitte Africa

# Leading strategies in focus

## **Make direct connections**

Building relationships with communities is akin to building any other relationship—it takes both time and personal attention. This makes it critical for mining company management to engage directly with key stakeholders to build consensus and brainstorm solutions to shared challenges. Notably, ongoing technological innovation is introducing a range of solutions miners can use to connect directly with community stakeholders. Cloud-based stakeholder engagement platforms, for instance, allow mining companies to more rapidly address time-sensitive complaints or grievances, while enabling more transparent stakeholder engagement. Similarly, the proliferation of mobile phones in remote communities gives companies another avenue to connect with local workers and keep the lines of communication open.

## **Correct misperceptions**

Part of the mining industry's challenge in fostering more effective community and government ties links to its bad reputation. Simply put, mining companies have not

traditionally done a good job engaging people's hearts and minds. This needs to change. Mining companies must work harder to display the positive contributions they make to community stability, environmental rehabilitation, and global economic growth—so that politicians are properly informed. They should spell out the huge range of consumer products, applications, and services that wouldn't exist without minerals and metals—and this isn't just cell phones, cars, airplanes, and roads. It's anything that relies on electricity, which wouldn't run without copper or other conductive metals. They should work to make their reports more user-friendly, digestible, and emotionally relatable. And they should encourage their people to spend more personal time changing minds—by visiting local schools, speaking at non-industry conferences, and inviting university students to not only tour mine sites but to shadow their professionals who are working at the leading-edge of technological innovation.

## **Plan now for the future**

There are few certainties in life, but in mining we know that every ore body has a limited lifespan. Mining companies need to understand how they can create a sustainable economic environment post closure. The actions and investments taken now can help spur new areas of economic activity which can sustain these communities long after the ore body has been mined out. In many cases, this is about leveraging existing infrastructure, but doing so with closure in mind.

## **Be transparent**

Many countries report experiencing Gross Domestic Product (GDP) leakage as a result of illicit financial flows and unauthorized commodity exports. To build goodwill and enhance transparency, mining companies could begin to use blockchain to track the flow of both their minerals and their royalty and tax payments, providing governments with immutable evidence of their compliance with local laws.

### Share ideas

Given the frequency with which lockouts and protests interrupt mining operations, it is clear that community dissatisfaction directly affects shareholder value, creating a business case for investor relations and sustainability teams to collaborate in the identification of strategies for engaging communities in more effective ways. This may mean redirecting investment to various local initiatives, arranging for executives to spend more time communicating directly with key stakeholders, or identifying opportunities to partner with other organizations to deliver greater community value.

### Prove it

One of the ways mining companies are demonstrating their commitment to local community initiatives is through the release of sustainability reports, which outline not only their environmental programs, but also their local community contributions, health and safety performance, and global tax payments. To add a further layer of credibility to these reports, some companies seek out third-party assurance for their claims, providing unbiased proof that they are walking their talk.

### From left field

If miners crack the code on generating value beyond compliance, and succeed at delivering both financial returns and making a defined social impact, could mining companies attract the interest of impact investors? If so, they could gain access to an impact investing market currently valued at over US\$228 billion.<sup>28</sup>



# Exploring the water-energy nexus

## Making the case for a systematic approach

As one of the world's most energy and water intensive industries, the mining sector has long struggled to secure uninterrupted access to these critical inputs. In recent years, this has spurred companies to action.

For instance, to reduce their energy costs, which can account for up to 30 percent of a mine's operating expenses<sup>29</sup>, many companies have begun adding renewables to their energy mix, and electrifying equipment and processes that run on fossil fuels.

While there is still room for improvement, progress is being made. Between 2008 and 2017, Rio Tinto reduced its greenhouse gas (GHG) emissions intensity by 27 percent. Today, approximately 75 percent of the company's energy comes from hydroelectric, nuclear, and renewable power sources<sup>30</sup>. Similarly, Antofagasta's Los Pelambres mine in Chile relies on renewables to generate roughly 45 percent of its energy<sup>31</sup>. Most recently, the company announced that its Zañavar copper mine in Chile,

which it jointly owns with Barrick, will begin operating with 100 percent renewable energy by 2020—a move that will enable the company to reduce its annual GHG emissions by 350,000 tons<sup>32</sup>.

As these leading companies have learned, however, true value from energy management can only be derived by addressing the triple bottom line of social, environmental, and financial performance. This requires companies to manage their energy related projects as

a portfolio and approach energy management as an integrated corporate initiative. Companies that succeed in this effort can reduce their energy consumption by 15 to 20 percent in existing mines, and up to 50 percent for new mines by rethinking the mine design with energy management in mind<sup>33</sup>.

### What about water?

Yet energy is not the only input at risk. In fact, water has quickly risen to the top of mining company agendas as one of the greatest constraints to supply. In regions around the world, mining companies must now contend not only with risks around water scarcity, but also those associated with excess rainfall, which can result in flooding.

According to the Climate Disclosure Project (CDP), 25 percent of mining

production, representing up to US\$50 billion in annual revenue, could face water shortages and drought by 2030<sup>34</sup>.

Environmental concerns around water quantity and quality are also exacting financial, operational, and reputational tolls. Mining companies around the world now face elevated regulatory risks relative to their use of water and community opposition that has sparked protests, operational disruption, and heightened levels of conflict.

As competition for water supplies mounts, many mining companies are taking steps to reduce water consumption, treat wastewater so that it can be recycled, and adopt innovations such as dry processing. These efforts, however, are often approached as isolated initiatives rather than enterprise-wide opportunities to achieve cost

savings, improve environmental performance, and enhance regulatory compliance.

Part of the challenge lies with the fact that mining companies do not yet have a business case around reducing water intensity equivalent to the one around reducing energy intensity. As a result, most companies continue to take a haphazard approach to water management—one that fails to integrate the health, safety, and environmental (HS&E), sustainability, and finance departments, preventing the identification of cross-functional opportunities to manage both water and energy in tandem.

With the stakes rising, it is becoming clear that a systematic approach to water management is required.



### Sustainability in action

Goldcorp continues to make strides in the execution of its Towards Zero Water (H2Zero) strategy. The company has already created a model to calculate the true cost of water usage in its mining operations, taking infrastructure, energy, and labor costs associated with extracting, pumping, transporting, storing, treating, and discharging water into account. Its EcoTails™ system blends filtered tailings with waste rock in transit to create a geo-technically stable product called GeoWaste—a solution that may help the company eliminate tailings dams entirely.<sup>35</sup> Not content to rest on its laurels, Goldcorp is also building the world's first all-electric mine, a move it anticipates will help it reduce its GHG emissions while saving roughly US\$9 million per year on diesel, propane, and electricity.<sup>36</sup>

### A solid foundation

The good news is that many companies have already begun laying the foundation by tackling energy management at a portfolio level. Building on these learnings, mining companies have a framework they can adapt to their water management efforts.

For new mines, this generally begins by gaining a solid understanding of available local water sources by conducting both hydrogeological and surface water studies, and conducting water supply and storm water modeling, a critical first step given that governments in most mining regions lack baseline data on local water availability. By providing mining companies and regulators with an understanding of how mining operations may affect the local ecosystem, this assessment can

help streamline the regulatory permitting process and enable companies to put systems into place to avoid unintended environmental consequences.

Armed with this knowledge, companies can integrate both water and energy management best practices into their mine designs. This may include relying on dry processing methodologies, reducing the amount of water required to store tailings, and even mining in ways that reduce impacts to surface and groundwater systems.

For mines already in operation, a good starting point would involve measuring water consumption across different sites and processes to create a baseline for water costs across the entire system. Currently, limited use of sensors means water sampling is

only conducted periodically and collected data remains unconsolidated, resulting in delays in both analysis and government reporting.

With digital technologies and advanced analytics, however, mining companies can measure and monitor their water flows on a continuous basis to analyze water quality, assess their water intensity, and identify severe water incidents in real time. This, in turn, can help them assign a financial value to water, allowing them to build a business case to conserve water (e.g., through drip leaching or ore sorting), enhance efficiency (e.g., through selective mining or high-intensity blasting, which results in less water for grinding), and find alternatives to the use of fresh water (e.g., through desalination or water recycling).





### Sustainability in action

As part of its FutureSmart Mining™ Sustainability Strategy, Anglo American is gearing towards the development of a waterless mine. At its Mogalakwena platinum mine in South Africa, it is using a fibre optic solution to measure mine-wide water flows to gain real-time insight into its water balance—empowering it to pursue the highest-impact efficiencies. It has also deployed a fibre optic solution in Chile to monitor its tailings dams, giving it the capacity to mitigate potential damages that could be caused by structural movements, long-term deformation, or creeps into dam foundations.<sup>37</sup>

### Riding the upside

There is also a significant upside that has yet to be quantified but that unquestionably exists: reducing water intensity can help to reduce energy intensity, and vice versa. By approaching energy and water management in tandem, mining companies can make business choices that optimize the use of both.

While these changes will not be easy, they are increasingly necessary if mining companies hope to maintain productivity, lessen community concerns, and manage their environmental risks in an energy and water constrained world.

“With a constant knowledge of how every drop of water is being used, and an understanding of all the parameters associated with its use, mining companies can manage water in the way they have begun to manage electricity, as a valuable resource.”

### Patricia Muricy

Mining & Metals Leader,  
Deloitte Brazil









# Decoding capital projects

## Learning from past mistakes

Although the recent commodity price meltdown has spurred many mining companies to operate leaner, it also whittled segments of the industry down. Among the investments that fell by the wayside were major capital projects. Burdened by years of sub-par returns, cost overruns, and impairment charges, many mining companies opted to concentrate on maximizing output from their existing operations rather than investing in new mine supply and exploration.

As a result, industry capital expenditures in new developments in 2017 fell by almost two-thirds compared to the US\$80.8 billion peak of

2012 (see figure 5). Grassroots exploration spend is at historic lows, while headcount and internal project capacity have seen cutbacks in response to cost-reduction strategies.<sup>38</sup>

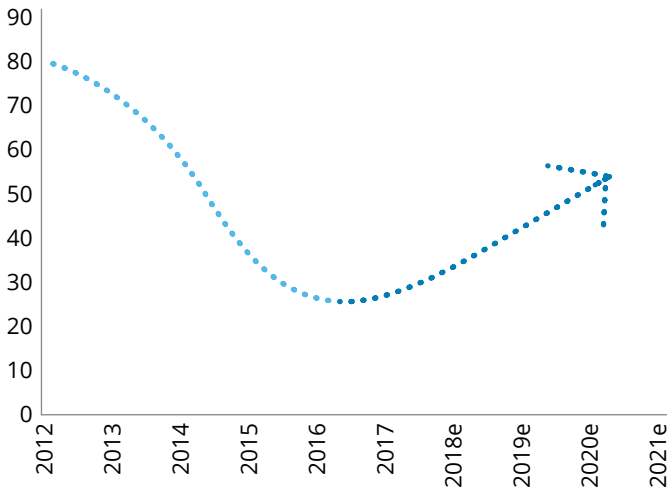
### Reframing reserve replacement

The consequence was inevitable: supply shortages for commodities such as copper, zinc, cobalt, lithium, and gold now loom, and no amount of squeezing of current deposits will cover the shortfall.

With the cycle turning, mining companies will need to engage in a wave of new capital projects to offset production declines and meet demand, a prospect that raises concerns

among mining executives, boards, and investors alike.

The worry is understandable. After all, this is an area that has traditionally been value destructive to the industry. Yet, despite their concerns about realizing sustainable returns, miners cannot avoid putting off capital project investments indefinitely. Instead, they must learn from the mistakes of the past by approaching capital projects with a new frame—one that sees them honing stronger organizational capabilities across their entire portfolio of projects rather than reinventing the wheel and assembling new teams on a project-by-project basis.

**Figure 5: Mining industry greenfield capex**

Note: Mining capex has declined heavily since the US\$80B+ peaks of 2012. Our analysis, based on company capex guidance and market sentiment, indicates that capex is increasing even with a modest growth rate, investment could exceed US\$40B in 2020.

Source: S&P Market intelligence, Deloitte analysis

### Building on their strengths

In fairness, they're not starting from a zero base. Stricter capital allocation frameworks mean investment decisions are now more rigorous, with heightened scrutiny of business case risks. More centralized business models facilitate greater control of capex. Significant industry investment in digital

innovation also promises to drive operating efficiencies.

But the goal posts have moved too. A lack of shovel-ready projects in "friendlier" jurisdictions is forcing miners to move up the geopolitical risk curve, often exposing them to heightened government expectations and resource

nationalism, and putting pressures on project margins and viability. Consolidation of major engineering, procurement, construction management (EPCM) contractors has left fewer suppliers to meet the growing demand. Lower headcounts in owner project teams is also leaving skills gaps.



### Capital project capacity in action

The Tideway project is a near US\$6 billion investment in the delivery of a 25 kilometer tunnel, 65 meters below the River Thames in central London. To enhance delivery success, the project team established a new standalone entity to manage the needs of multiple external stakeholders. The target operating model design considered the organization's capability requirements at key phases of the project's lifecycle, focusing on the optimal owner's team structure and core in-house capabilities needed. This innovative delivery model allowed the right capabilities to be in place at the right time.<sup>39</sup>

### Five areas of focus

To overcome these challenges, mining companies must build their maturity in five key areas:

#### Delivery models

While mining companies have traditionally relied on EPCM and engineering, procurement and construction (EPC) companies to deliver major projects, they have often struggled to effectively manage these relationships. Ultimately, the delivery model selected should determine the project team's set-up, where accountability lies, and how risk should be shared among delivery partners. This, in turn, should help companies align incentives with project and operational outcomes, consciously build the right level of capability to deliver on the project strategy, and adopt collaborative contractual mechanisms to drive continuous improvement throughout the project lifecycle.

#### Data and technology

Although mining companies have the technological capacity to capture a wealth of project information, siloed information systems hamper their efforts to effectively share this data across the supply chain. Without a standardized, cohesive version of the truth, decision-making is compromised—resulting in cost

overruns. Notably, companies that build a unified data model that enables consistent reporting and predictive analytics can realize capex savings of up to five percent.<sup>40</sup>

#### Project controls

Today's major projects are increasingly complex and under significant scrutiny, mandating the adoption of highly-effective project controls. To get this right, project controls must be adopted not only during a project's execution phase, but also during pre-feasibility and feasibility studies, and during the transition to operational readiness. The aim should be to apply owner-led project controls across all operating model layers—including organization, process, technology, data, and governance—and to continuously use them to monitor project performance so emerging issues can be remediated before they can derail the project.

#### License to operate

Even with the best delivery models, data insights, and project controls, mining industry capital projects can still be rushed due to poor environmental performance, troubled community relations, or regulatory non-compliance. This means capital project

success also hinges on corporate willingness to deliver shared value to local communities and supply chain partners. To build more effective relationships, consider monitoring and transparently tracking efforts to provide local communities and suppliers with an economic dividend, developing a detailed plan of commitment activities, and integrating them into the wider project scheme (see Trend five for more detail).

#### Collaboration

Although mining companies have taken significant steps to optimize their portfolios, they still struggle to respond to shifting macro-economic trends, which make long-cycle megaprojects particularly risky. Yet rather than sharing the burden of this risk through collaboration, many mining companies continue to “go it alone”, tying up more capital over the long term and missing potential opportunities. To better share risk and drive innovation, mining companies should aim to expand their partnership ecosystem by pursuing grassroots partnerships with juniors and entering into joint ventures to uncover new deposits.



### Capital project capacity in action

To optimize maintenance costs and production processes for 900 kilometers of railway, one global miner adopted technologies such as image recognition, sensor data, text mining, machine learning, and data visualization to enable predictive maintenance for its rail infrastructure. This allowed it to remediate emerging issues in a controlled fashion—increasing rolling stock availability, optimizing asset performance, and reducing the risk of accidents.<sup>41</sup>

### The upside

After the challenges faced during the last down cycle, there is a palpable sense of optimism for mining companies as commodity demand picks up. Before launching into the next wave of investment, however, the lessons of the last cycle must be learned and the industry needs to rebuild trust with stakeholders in its ability to deliver longer-term value. Although this won't happen overnight, organizations that focus now on putting the right capital project capabilities into place can strengthen their capacity to adjust supply in response to shifting demand patterns.

### Right from the start: Building digital mines from the ground up

Capital project planning takes years, which likely explains why no digital mines have yet to be built from the ground up. However, advances in finance platforms, sensor technology, autonomous vehicles, cloud-based solutions, and analytics are changing how capital projects of the future will be delivered—paving the way for the design of a digital mine.

Some global leaders are already deploying new technologies into classic plants to test their efficacy, mitigate risks, and strengthen their capacity to standardize their global footprints. As the industry's digital maturity grows, we may ultimately see capital project "superhighways" enabled by data-driven project planning and execution, and an augmented workforce armed with new capabilities.

The conceptual structure already exists and would see mining companies approach capital project planning by developing an enterprise-wide digital strategy directly linked

to business value; automating operations and digitizing assets from the outset; eliminating data silos by establishing an integrated digital mine nerve center; implementing supporting platforms and enablers; and equipping their diverse and distributed workforce with the skills to operate in a connected fashion.

Most critically, the future is here. The technologies to make the digital mine a reality are currently available, positioning leading miners to realize new frontiers of capital project efficiency and control.

"As capital projects begin to pick up, mining companies will need to avoid the mistakes of the past by rethinking their delivery models, adopting appropriate governance processes, and ensuring they have the skills in place to manage performance across the entire project lifecycle."

#### Tim Biggs

EMEA Mining & Metals Leader  
Deloitte UK

# Leading strategies in focus

## **Get analytical**

Thanks to advances in digital technology, tools now exist that allow mining companies to monitor their portfolio of capital projects at the operational, tactical, and strategic levels. By integrating information from planning systems onto a single platform, these solutions can provide insight into subcontractor productivity, health and safety performance, and physical and financial progress of individual projects and programs—positioning organizations to make more informed management decisions.

## **Become digital**

To deliver data-centric capital projects, mining companies need to shift from “doing digital” to “being digital”. This involves investing in data standards, embedding a unified data model, and treating data as an asset by ultimately setting up a digital twin to support project success during the transition to operations.

## **Learn from other sectors**

To reduce the risk of major capital projects, oil and gas companies often engage in shorter-cycle projects designed to rapidly generate a positive cash flow. In addition to reducing capital expenditures, these short-cycle investments

help to preserve production capacity and ensure portfolio agility. For mining companies, a phased approach to the largest investments could spread risk in a similar fashion.

## **Model**

Early-stage projects should be continuously evaluated. Flexible, driver-based modeling gives visibility of multiple “what if” scenarios to support decision-making in line with the overarching strategic vision. Rolling this information into a single consolidated view can help mining companies make decisions that properly assess macro and project risks at a portfolio level.



# Reimagining work, workers, and the workplace

## A blueprint for the future

Mining executives are no strangers to shifting workforce realities. The relentless drive towards digitization and automation has altered not only where work takes place (e.g., remote operations/telework), but also the nature of corporate talent needs. As highly repetitive transactional work is automated, the demand for people with broad foundational skills, as well as deep technical expertise, will only rise.

At the same time, the mining industry now faces a massive generational shift. In Canada, 50,000 mining workers, representing roughly

26 percent of the current workforce, are expected to retire in the next ten years.<sup>42</sup> With enrolment in mining-related disciplines down, filling those talent gaps will be no easy task. In Australia, for instance, enrolment in mining engineering courses fell from 292 in 2014<sup>43</sup> to 171 in 2017, and is projected to drop to an alarming 47 by 2020.<sup>44</sup>

This generational shift is by no means confined to frontline workers. Recent announcements of planned exits by C-suite executives have brought the imperative of succession planning to the

fore and are putting mining companies under pressure to more clearly articulate the leadership attributes they anticipate will be most vital for the future.

The very nature of careers is also changing. Not only is job and career-hopping becoming the new norm, but a younger generation of workers now measures loyalty to an employer in months instead of years. As a result, mining companies need strategies for recruiting these so-called “gig workers”, the networks of people who will increasingly form tomorrow’s contingent workforce.





### The future of work in action

To retain its coveted IT specialists and enhance employee engagement, Norilsk Nickel in Russia developed an employee motivation solution based on blockchain and the cryptocurrency WorkCoin. It has used the system to “gamify” the technology innovation process by enabling staff to “compete” to solve complex problems and earn virtual points, which can be redeemed for non-monetary awards, such as prizes and promotions.<sup>45</sup>

### Firing on all cylinders

To prepare for this imminent future, mining companies are beginning to broaden their talent strategies. The key is to consider not only the shifting nature of work, but to determine how to attract a new breed of workers and tailor their workplaces accordingly.

When it comes to redefining the future of work, organizations need to clarify not only their business goals and aspirations, but also the role that talent strategy should play to deliver on them. This involves looking at specific tasks within each role and whether these could be disrupted by technology, now or in the future. It also involves identifying any current talent and organizational gaps that must be bridged to support the future direction of the business.

As a second prong in this strategy, companies will need to identify the workers of the future by considering what the employee experience will look like, and the role that innovation will play in that experience. Going forward, companies will have many more options to choose from to carry out specific tasks with an ability to also draw on gig economy workers, crowdsourcing options or outsourced talent models. In making this determination, mining companies should consider how employee needs are changing and which needs remain unmet. This should help guide the strategies they choose to adopt regarding how to attract and retain top talent, what partnerships they must leverage to access in-demand talent, and who should manage and lead the workers of the future.

Third, organizations must consider what the workplace of the future will look like. This means reconceiving how employees will interact with each other and conduct their work, be it in a physical location or conducting that work remotely. The technology infrastructure to enable this workplace will also change and new collaboration and interaction models will need to be developed.

Throughout the entire process, companies also need to think through how they plan to measure success, by identifying critical key performance indicators (KPIs), setting baselines for employee engagement, and tracking how well they iterate their approach to easily adopt new technology and scale their initiatives.



### The future of work in action

As miners grapple with the challenge of rebuilding their skill base and developing a workforce capable of bringing the industry along the technology pathway it needs to remain competitive, they must find new ways to motivate their workforce. BHP has approached this challenge with its “Think Big” campaign which, among other things, saw BHP employees filmed at their workplace and talking about their company<sup>46</sup>. The campaign helped to evoke a sense of pride and commitment, as well as a collective mind-set that gave employees the authority to “own” problems and challenges, rather than delegating them to someone else.

### Inventing the future

In the face of AI, mobile platforms, sensors, and social collaboration systems that continue to revolutionize lives and workplaces, employees and organizations are more overwhelmed than ever. For the mining industry, already burdened with a perception problem among young people considering career choices, the need for new and robust ways of redefining work, workers, and the workplace is becoming urgent. Yet, if fortune truly does favor the bold, mining executives who adopt new talent approaches are not just preparing for the future of work, but are helping to invent it.

This is not mere posturing and neither is it contained to just the

back office, all roles including operational, have the potential to be disrupted. As the mining industry prepares for the future of work, jobs will need to be disaggregated and broken down into individual tasks so that companies can identify the best resources to complete each task—whether that’s traditional employees, outsourced talent, or digital technology. The ideal end state is to automate the tasks that don’t add value, while giving the right people the opportunity to complete the tasks that interest or challenge them most.

When jobs are broken down in this way, it becomes clear that automation is not synonymous with job loss. Instead, task-level analysis gives companies

a tool for properly defining the jobs of the future. Low level, manual, or transactional tasks are automated or outsourced, and whatever is left over—including tasks that contribute to the corporate mission or relate to core strategy—can be reconstituted into new job functions.

Once each task is charted in this way, mining companies can begin to build a vision for their future workforce—road-mapping the skills they believe will be in greatest demand. This allows them to become masters of their own future—designing programs that enable them to fill their talent gaps before competitors have even identified which gaps exist.

“There are countless tactical steps mining companies can take in setting the foundation for the future of work. But none of them will be effective unless the C-suite comes together to define their vision of the future and allocate resources against that vision.”

### Janine Nel

Global Human Capital Energy, Resources & Industrials Leader  
Deloitte Africa

# Leading strategies in focus

## **Build a symphonic C-suite**

Mapping out the workforce of the future is not a task for HR, operations, IT, or individual mining sites. It requires the C-suite to work together across functions to address each element of the challenge from a people, process, and technology perspective. The symphonic C-suite is a new leadership model where an organization's top executives play together as one team, while leading their functional teams, to drive more agile organizations. In this model, C-suite members not only lead their own area of responsibility, but also collaborate with other functional leaders, work on teams that affect the enterprise's strategic direction, and influence and inspire networks of teams throughout the organization. For instance, this could see the Chief Information Officer (CIO) and Chief Financial Officer (CFO) working with business leaders, supply chain executives, and the Chief Human Resources Officer (CHRO) to pilot and implement new automation solutions and redesign work around these new platforms.

## **Manage beyond the enterprise**

As the nature of work changes, the gig economy is forecast to grow. This mandates mining companies to extend their talent approaches to gig and contract workers by giving them performance goals, secure communication systems, training and support, and access to onboarding and development opportunities.

## **Rethink rewards**

According to recent research, the current reward system within most organizations is broken. To meet shifting expectations, organizations are now being called upon to offer more personal and agile rewards. This may include providing raises and bonuses more than once per year, offering incentives to contract workers, and making salary decisions more transparent. One European consulting firm, for example, allows employees to choose their preferred rewards, such as salary or stock options, an extra week of vacation or higher pay, or a higher bonus based on results versus a lower increase in base pay.<sup>47</sup>

## **Think beyond safety**

While safety is of paramount importance, mining companies committed to retaining key talent must extend the definition of employee well-being to physical, mental, financial, and even spiritual health. This expanded definition could see companies emphasizing new priorities, which may include maintaining a healthy work/life balance for staff, avoiding fatigue from 24/7 work cycles (perhaps by using a "follow the sun" approach in running remote operating centers), using wearable technologies to monitor workers' physical health, providing fitness and stress management programs, and strengthening the culture of diversity and inclusion.

## **Empower leadership**

In the face of flattened and changing hierarchies, leaders need the ability to handle greater cognitive complexity and must be comfortable with failing early, failing fast, and learning faster. If leaders cannot model these new behaviors, employees will hesitate to embrace them, and change will be relegated to a concept rather than helping to shape and drive new workforce realities.

### **From left field**

Millennials value experiential travel and immersive adventures—experiences they could arguably get working in remote mining locations. Could mining companies possibly attract a new generation of workers by "selling" these jobs as immersive experiences, and devise more powerful retention strategies that encourage them to stay?



# Operationalizing diversity and inclusion programs

## From theory to practice

Like many traditionally male-dominated industries, mining has an inconsistent record when it comes to workplace diversity and inclusion. In 2016, when Chile's Ministry of Mining conducted a survey of 603 women in the industry, it found that more than 40 percent had been subjected to cruel jokes and wolf-whistling, 20 percent had been groped, and seven percent had been sexually propositioned.<sup>48</sup> The recent establishment of a MeTooMining Association, which is advocating for strong programs against intimidation,

gender discrimination, and sexual harassment and violence in the workplace, also suggests that mining companies need to take a closer look at their inclusion strategies.

### Positioning for change

Many mining companies have arrived at a similar conclusion, and have begun setting targets for gender equality and greater cultural inclusivity. With advances in technology, such as trucks equipped with power steering, and automation that enables the remote operation of equipment, new opportunities are opening up for a very

different workforce. BHP has an aspirational goal to achieve gender balance across each of its global operations by 2025.<sup>49</sup> Freeport-McMoRan continues to work towards its target to increase women in its global workforce, as well as women in managerial roles, to a minimum of 15 percent.<sup>50</sup> For its part, South32 aims to have women holding 40 percent of its senior leadership positions by 30 June 31 percent today.<sup>51</sup>

Meeting these diversity targets is not only the right thing to do; it is also sound business practice. According to BHP,

its 10 most-diverse mines outperformed its other sites by roughly 15 percent over the past three years.<sup>52</sup> Similarly, in 2016 Rio Tinto reported that both its safety and equipment maintenance performance was higher at its most diverse operation.<sup>53</sup> Most critically, miners will struggle to meet their digitization, automation, and innovation goals if they cannot attract what is quickly becoming the most in-demand cohort of talent in the world, and doing that will require them to expand their diversity and inclusion practices.

### Culture and numbers

Setting targets and reaching them are two different things, particularly given the lack of diverse talent in the mining

industry. Even counting the 1,800 women BHP hired in 2017,<sup>54</sup> it still needs to recruit more than 19,000 women by 2025 to reach its gender parity target,<sup>55</sup> and it must do so at a time when its global counterparts are competing for the same talent.

The challenge then, is not simply cultural. It is also numerical. Right now, the mining industry is not attracting sufficient numbers of diverse candidates to truly move the dial on its diversity and inclusion strategies. To shift this balance, companies will not only need to change their talent attraction and retention policies. They will also need to change historical perceptions about the mining industry itself.



### Diversity and inclusion in action

To meet its aggressive diversity and inclusion targets, BHP has devised a strategy focused on four core goals: to achieve gender parity, build a flexible work program that meets the needs of all employees, enhance education and awareness, and develop more diverse leaders. Rather than confining its program to head office, the company is re-examining how work is done at its sites by analyzing hundreds of jobs to assess if they can be performed in more flexible ways. The entire program is underpinned by the understanding that safety must remain paramount, operational continuity and productivity will remain unaffected, and opportunities will be generated for all employees, not just women. After considerable discussion, the company concluded that some of its job functions could be performed in non-traditional ways. To this end, it formulated levels of flexible work options and will be rolling the program out imminently.

### Getting tactical

As a first step, mining companies must adopt solid strategies to foster organizational diversity and inclusion. It's not that they haven't looked at this issue before. It's that they often approach this issue by adopting point initiatives, rather than designing integrated programs to tackle the challenge holistically.

For instance, while most mining companies are working with educational institutions to interest students in the industry, their approach is haphazard and uncoordinated. As a result, each company is telling a divergent story, diluting the core messages they could otherwise convey if they came together as an industry to craft a cohesive narrative.

Attraction strategies should also be geared to a more diverse audience. Online platforms exist that help organizations create advertisements targeted to specific demographics—which can help them attract a more diverse range of candidates.

Gender diversity is not the only target that mining companies are introducing. One mining company is targeting to have one percent Neurodiversity in their technology team in a couple of years. In an environment where data scientists, for example, are in short supply, this may open up a new stream of talent that previously was overlooked. They have introduced new recruiting, coaching, teaming and performance strategies to facilitate an integrated and tailored new way of working for these highly talented individuals.

These are the actions that are required in the pursuit of talent in today's environment.

Retention is another area that needs reform. When companies do attract women, they often struggle to retain them, in part because they fail to deliver simple solutions—such as safety equipment designed to fit women's bodies, higher quality accommodation, a broader variety of healthy food options, and a wider range of social activities. Other programs—such as pay equity, workplace flexibility, parental leave, and support for employees who are acting as caregivers, must also become table stakes. To assess which initiatives work, and which don't, companies should track results so they can analyze outcomes and adapt accordingly.





### Diversity and inclusion in action

In a bid to create more employment opportunities for Australia's Aboriginal community, Fortescue Metals Group supports a range of programs that have made a fundamental difference over the years. In 2011, it established its Billions Opportunities program through which it has awarded 270 contracts and sub-contracts to 110 Aboriginal-owned businesses and joint ventures, for a total value of AUS\$2 billion (approximately US\$1.44 billion). Fortescue's Vocational Training and Employment Center (VTEC) has helped over 1,650 Aboriginal people through employment, driving lessons, resume creation, accommodation, and personal development since 2006. Its Leadership and Excellence in Aboriginal People (LEAP) initiative offers 12-month formal training that includes both offsite and onsite education, internal mentoring, and business leadership training. In financial year 2018 alone, the company spent AUS\$230 million (approximately US\$166.29 million) with 52 Aboriginal businesses and 1100 Aboriginal people worked across their operations.<sup>56</sup>

### Exposing unconscious bias

Beyond the tactics, however, a more fundamental shift needs to take place, one aimed at disrupting often unexplored cultural norms and stereotypes. This is not simply about changing the way minorities are treated. It's about exposing unconscious biases that influence hiring decisions and contribute to workplace inequality. To do this effectively, organizations need to cascade training down to the operational level, where hiring decisions are

being made. They must also be willing to examine the ways in which things have "always been done", for example, by giving a larger cohort of workers access to cross-border opportunities, by expanding their parental leave policies to include both men and women, by rethinking how to incorporate workers with disabilities into the organization, and by removing any systemic and inherent biases that have crept into their policies and processes.

### An image overhaul

In tandem with shifting the way they operate, mining companies must take steps to amend their public image. This starts with the literal visual image companies portray on their reports and in their advertisements. While many companies have begun to include pictures of women on their marketing materials, they are still generally pictures of women on high beams and

wearing hard hats, rather than women and men operating remote equipment or engaging in technological innovation. This representation links to the narrative mining companies continue to tell themselves about what they stand for—and until mining companies start telling different stories about themselves, cultural transformation cannot take place (see sidebar).

As industry efforts show, diversity and inclusion are proving to be much more than a flavor of the month. However, mining companies have a long road ahead before they can turn these programs from vision into reality by permanently weaving new behaviors, attitudes, and policies into the fabric of their organizations.



#### Diversity and inclusion in action

Antofagasta is training 400 executives in inclusive leadership and unconscious bias. It participates in a gender-equality initiative with the IMF and the Inter-American Development Bank, while five of its supervisors are part of the Proyecto Promociona, a program to help women break through the glass ceiling.<sup>57</sup>

“Diversity and inclusion is a problem. The industry has been on this journey for many years and has not yet moved the dial in any significant way. It’s time for mining companies to go beyond training and change management, and explore the operationalization of more flexible programs, especially on mine sites.”

#### Karla Velásquez

Mining & Metals Leader,  
Deloitte Peru



# Leading strategies in focus

## Go grassroots

Systemic change has to happen from both the top down and bottom up. By supporting grassroots organizations, mining companies can help encourage greater diversity across the industry. International Women in Mining, for instance, is the fastest-growing network for women in the mining industry<sup>58</sup>. It aims to provide a global platform for all women in mining by supporting initiatives that improve diversity and foster women's professional development. There are also countless regional initiatives mining companies can support. In Canada, for instance, Women on the Move is working to bring women-led businesses into the mining supply chain as part of an overall strategy to encourage the science, technology, engineering, and math (STEM) industry to procure products and services from women entrepreneurs.<sup>59</sup>

## Root out unconscious bias

Inclusive leadership training does not aim to change a

manager's leadership style or shift an organization's leadership model. Instead, it's designed to help leaders adopt specific behaviors that build more inclusive environments and generate change. There are six traits we believe demonstrate inclusive leadership, including cognizance, curiosity, courage, cultural intelligence, commitment, and collaboration. Together, these traits can help leaders overcome cognitive biases, encourage new ideas, talk about imperfections, and acknowledge diverse cultural frames of reference. Ultimately, this comes down to how a company's people act every day, what they do or don't say, and the metrics used to hold people accountable.

## Redesign work

By creating more flexible work environments, mining companies cannot only attract a wider range of talent, but they stand to gain operational benefits too. Before these efforts can yield results, however, executives need to

understand that true flexibility is about how work is done, not where work is done. In other words, flexible work is not about creating off-site jobs. It's about rethinking how on-site jobs can accommodate different working styles—through such things as flexible shifts, access to short-term leave, or allowing people to come back to work after an extended sabbatical. Introducing these changes to an industry characterized by remote locations, projects that run on a 24-hour basis, and health and safety rules that restrict multiple rosters will be no easy task—but leading mining companies are already demonstrating that it is possible.



## Demanding provenance

### EVs and battery minerals provoke the desire for provenance

While it may not be a full-scale revolution, the electric vehicle (EV) boom stands to reshape numerous industries and global automakers have been positioning themselves to compete in this space for years.

The Nissan LEAF, now in its second generation, is the best-selling electric car in the world.<sup>60</sup> Due to higher than anticipated demand, General Motors announced plans to increase production of the Bolt, and remains committed to introducing at least 20 new electric vehicles by 2023.<sup>61</sup> Since

introducing its all-electric EQ brand in 2016, Mercedes has been investing billions of dollars into the EV space and plans to bring more than ten different all-EV vehicles to market by 2022.<sup>62</sup> Volkswagen (VW) just recently unveiled its modular electric drive matrix (MEB) platform to support its vision of 'Electric for all', and plans to roll out a minimum of 100,000 electric cars per year by 2020 in its first German plant slated to go electric.<sup>63</sup> For its part, BMW is entering the second phase of its electrification strategy, with its

iNEXT technology flagship expected to roll out by 2021.<sup>64</sup>

#### Driving demand

All this is music to the ears of mining executives, who are now positioning to meet the spiraling demand for EV battery materials, such as lithium, cobalt, rare earths, graphite, nickel, and copper.

The demand forecasts are considerable. By 2035, demand for copper is expected to reach 11 million tons, and that's for EVs alone.

An additional 1.2 million tons may be needed to build charging stations and upgrade distribution lines.<sup>65</sup> Between EVs, global energy storage, and nanotechnology, the global demand for tech-grade graphite is set to rise by 200 percent by 2020 and 300 percent by 2025.<sup>66</sup> Demand for cobalt and lithium is also expected to double between 2022 and 2025.<sup>67</sup>

The good news story doesn't stop there. The rapid adoption of EVs may accelerate the development of other competing technologies, such as those fueled by hydrogen cells. In fact, China anticipates having one million hydrogen fuel cell vehicles on the roads by 2030. The country already has 12 hydrogen fueling stations in operation, with 19 under construction, and is aiming for at least 100.<sup>68</sup> This may heighten demand for commodities such as platinum, which is used in hydrogen engines, a potential future scenario that has spurred Anglo American

to invest US\$100 million in two venture capital funds that will invest in companies developing innovative uses for platinum.<sup>69</sup>

### **The price of poor provenance**

All that said, supply risks exist—and these go beyond the challenges associated with ramping up production. One of the prevailing concerns revolves around an over-reliance on cobalt originating from the Democratic Republic of Congo (DRC), which controls roughly 70 percent of the world's cobalt supply and where human rights violations, including child labor, are common.<sup>70</sup>

This presents more than a risk of non-compliance with international labor standards. It is also exposing mining companies to a new form of scrutiny. That's because socially-conscious millennials are now questioning the provenance of raw materials in products ranging from cell phones to electric vehicles. As a result, downstream customers—such as automotive

manufacturers and technology giants—are demanding ethically-sourced minerals, and are willing to vote with their feet if miners can't deliver.

Apple stopped buying cobalt from artisanal mines in the DRC due to their dangerous working conditions.<sup>71</sup> Apple regularly maps its supply chain to remove suppliers unable or unwilling to comply with the company's ethical sourcing standards.

Outcomes like these are putting unprecedented pressure on mining companies to take the needs of their end users into account and create a more transparent interface with their customers. As strange as it may sound, commodities are increasingly being viewed as consumer products that will only attract top dollar if they possess certain quality thresholds related not only to their ore grade and energy density, but also to the impact their extraction has on societies, communities, individual workers, and the environment.

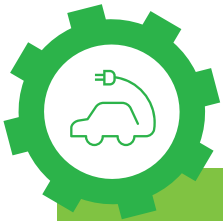
### Blockchain coming of age

This is driving the adoption of technologies such as blockchain to enhance the traceability of commodities. For instance, De Beers developed a blockchain platform called Tracr to digitally track diamonds from the mine to retailers. Mined diamonds are assigned a global diamond ID, which records their individual characteristics, such as carat, clarity, and color. When fully operational, Tracr will allow consumers to confirm that registered diamonds are natural and conflict-free.<sup>72</sup>

Although blockchain can be used for a variety of purposes in the mining industry—including transfers of value (accounts payable, trade finance, audit trails), digital identity (vendor management, shareholder voting), and smart contracts (supplier partnerships)—provenance is one of its most promising applications. By facilitating asset traceability from origin to destination, blockchain can validate the source of specific commodities across the supply chain to reduce the prevalence of conflict

sources, enhance transparency, and improve reporting and regulatory compliance.

It can also help mining companies instantly calculate and prove details such as product origin, custodial chain, and the end-to-end carbon footprint involved in producing any particular ton of ore. This will do more than position them to benefit from the EV boom. It will also enable them to further differentiate their offerings in the eyes of consumers, regulators, and investors—enhancing their long-term value.



### Transparency in action

Produits Artistiques Métaux Précieux (PAMP), a global bullion brand and precious metal refiner, recently entered a strategic alliance with Peer Ledger, a Canadian blockchain company, to create responsible sourcing software for supply chains. The platform allows customers to use an iPhone app to scan precious metal products to obtain both provenance and authentication information. By tracing precious metals to their original sources, this solution can help to prevent counterfeit and unethically sourced metals from entering the supply chain.<sup>73</sup>

“As customer demand for battery minerals rises, so too does the demand for transparent provenance. Mining companies that can respond rapidly may see a first mover advantage that allows them to earn a premium on their products.”

### Ian Sanders

Mining & Metals Leader  
Deloitte Australia





# Holistic, dynamic, and integrated

## Devising a grand strategy for the future

With commodity prices staging a comeback, the mining industry is poised for a new cycle of growth. Yet, unlike past recoveries, this one is unlikely to be characterized by rampant optimism, overspending, and unrealistic production goals. Battle-scarred and wary, today's mining companies have left their adolescence behind and are walking towards an uncertain future with greater maturity, humility, and courage.

To thrive amid the demands and exigencies that Industry 4.0 presents, mining companies will need a new strategic

approach, one that considers not only the full range of industry shifts and risks, but that provides executives with an enterprise-wide view of their value drivers. Decisions can no longer be made in silos, without an understanding of their global implications. Instead, data, processes, operations, systems, and teams must be integrated to ensure that critical actions align to corporate vision.

This requires mining companies to be willing to do more than learn from their past mistakes. It also requires them to be sufficiently open-minded

to resolve conventional challenges in non-traditional ways, ultimately transforming their approaches to risk management, talent attraction, community relations, supply chain systems, capital projects, portfolio structuring, and stakeholder relationships. Only in this way can mining companies position themselves to not only enhance financial performance, but to assume the mantle of responsibility for the social and environmental repercussions of their actions.

“It is now well-understood that mining companies cannot operate in isolation from one another. It must be equally understood that they cannot thrive by taking an isolated approach to their internal initiatives. Only by breaking down longstanding silos can companies hope to achieve the efficiencies, enhanced performance, and cost savings that come from working in harmony at an enterprise level.”

### **Rajeev Chopra**

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# Endnotes

1. Mining.com, March 8, 2016. "Infographic: The extraordinary metals in an iPhone 6s." Accessed at <http://www.mining.com/web/infographic-the-extraordinary-metals-in-an-iphone-6s/> on September 25, 2018.
2. Geology for Investors, Accessed at <https://www.geologyforinvestors.com/metals-electric-cars-revolution-making/> on September 25, 2018
3. Deloitte, 2016. "The bottom line: Driving value through energy management in mining." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-the-bottom-line.pdf> on September 25, 2018.
4. Water Online, August 2, 2018. "Global Water Market To Reach \$915B By 2023 As Oil And Commodity Prices Recover, New GWI Forecasts Reveal." Accessed at <https://www.wateronline.com/doc/global-water-market-to-reach-b-by-as-oil-gwi-forecasts-reveal-0001> on September 25, 2018.
5. Mining.com, September 20, 2018. "Rio Tinto's exit from coal pays off, to return \$3.2B from sales proceeds to shareholders," by Cecilia Jamasmie. Accessed at <http://www.mining.com/rio-tintos-exit-coal-pays-off-return-3-2b-sales-proceeds-shareholders/> on September 26, 2018.
6. Mining.com, June 29, 2018. "Rio Tinto ready to splash out on copper." Accessed at <http://www.mining.com/web/rio-tinto-ready-splash-copper/> on September 26, 2018.
7. Reuters.com, October 25, 2018. "Barrick Gold sees potential to expand Tier 1 assets." by Susan Taylor. Accessed at <https://www.reuters.com/article/us-barrick-gold-outlook/barrick-gold-sees-potential-to-expand-tier-1-assets-thornton-idUSKCN1MZ20X> on September 26, 2018
8. Dundee Precious Metals, July 31, 2017. "Dundee Precious Metals Creates Leading Technology Provider Through the Combination of its Terrative Digital Solutions Division With MineRP." Accessed at <https://www.dundeeprecious.com/English/Corporate-News/press-release-details/2017/Dundee-Precious-Metals-Creates-Leading-Technology-Provider-Through-the-Combination-of-its-Terrative-Digital-Solutions-Division-With-MineRP/default.aspx> on September 26, 2018.
9. Disrupt mining, Accessed at <https://disruptmining.com/> on September 26, 2018.
10. Reuters, March 29, 2018. "Goldcorp deposits 3,000 ounces of gold in blockchain milestone," by Susan Taylor. Accessed at <https://www.reuters.com/article/us-goldcorp-blockchain/goldcorp-deposits-3000-ounces-of-gold-in-blockchain-milestone-idUSKBN1H52QE> on September 26, 2018.
11. Forbes, May 21, 2018. "How Much Data Do We Create Every Day? The Mind-Blowing Stats Everyone Should Read," by Bernard Marr. Accessed at <https://www.forbes.com/sites/bernardmarr/2018/05/21/how-much-data-do-we-create-every-day-the-mind-blowing-stats-everyone-should-read/#7274a0d5460ba> on November 29, 2018.
12. Deloitte, August 2016. "IDO Playbook".
13. Mining Magazine, September 18, 2018. "Fluor taps into IBM Watson for digital transformation of EPC projects." Accessed at <https://www.miningmagazine.com/innovation/news/1346634/fluor-taps-into-ibm-watson-for-digital-transformation-of-epc-projects> on October 2, 2018.
14. [www.earth-ai.com](http://www.earth-ai.com), Accessed October 2, 2018.
15. Reuters, September 18, 2018. "U.S." gives rare earths reprieve in revised \$200 billion China tariff list," by Tom Daly. Accessed at <https://www.reuters.com/article/us-usa-trade-china-minerals/us-gives-rare-earths-reprieve-in-revised-200-billion-china-tariff-list-idUSKCN1LY0QK> on September 26, 2018.
16. Mining Weekly, June 15, 2018. "Resource nationalism on the rise in sub-Saharan Africa," by Nadine James. Accessed at <http://www.miningweekly.com/article/resource-nationalism-on-the-rise-in-sub-saharan-africa-2018-06-15-1> on September 26, 2018.
17. Mining Weekly, June 15, 2018. "Resource nationalism on the rise in sub-Saharan Africa," by Nadine James. Accessed at <http://www.miningweekly.com/article/resource-nationalism-on-the-rise-in-sub-saharan-africa-2018-06-15-1> on September 26, 2018.
18. Mining Weekly, June 15, 2018. "Resource nationalism on the rise in sub-Saharan Africa," by Nadine James. Accessed at <http://www.miningweekly.com/article/resource-nationalism-on-the-rise-in-sub-saharan-africa-2018-06-15-1> on September 26, 2018.
19. Deloitte Insights, December 1, 2016. "The rise of the digital supply network," by Adam Mussomeli, Doug Gish, and Stephen Laaper. Accessed at <https://www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-transformation-in-supply-chain.html#endnote-20> on October 23, 2018.
20. CNBC, June 22, 2018. "The modern mine: How digitization is transforming industry from pit to port," by Schneider Electric. Accessed at <https://www.cnbc.com/advertorial/2018/06/18/the-modern-mine-how-digitization-is-transforming-industry-from-pit-to-port.html> on October 23, 2018.
21. Mining Global, November 22, 2017. "Australia's Roy Hill maintains agility in mining," by Fran Roberts. Accessed at <https://www.miningglobal.com/company/australias-roy-hill-maintains-agility-mining#> on October 23, 2018.
22. Proceedings of the National Academy of Sciences, May 27, 2014. "Conflict translates environmental and social risk into business costs," by Daniel Franks, Rachel Davis, Anthony Bebbington, Saleem Ali, Deanna Kemp, and Martin Scurrah. Accessed at <http://www.pnas.org/content/111/21/7576.short> on October 3, 2018.
23. Harvard Business Review, November 10, 2017. "It's Never Been More Important for Big Companies to Listen to Local Communities," by Sinziana Dorobantu and Dennis Flemming. Accessed at <https://hbr.org/2017/11/its-never-been-more-important-for-big-companies-to-listen-to-local-communities> on October 4, 2018.
24. The Australian Mining Review, March 7, 2018. "Rio Tinto: The Bottom Line," by Elizabeth Fabri. Accessed at <http://australianminingreview.com.au/rio-tinto-the-bottom-line/> on October 4, 2018.
25. EITI, June 28, 2018. "Q&A with Rio Tinto," by Simone Niven. Accessed at <https://eiti.org/blog/qa-with-rio-tinto> on October 4, 2018.
26. Chamber of Mines of South Africa, November 2017. "News form the emerging miners' desk." Accessed at [file://sbssserver/Users/Tiny/Downloads/com-news-from-the-miners-desk-10-11-2017%20\(1\).pdf](file://sbssserver/Users/Tiny/Downloads/com-news-from-the-miners-desk-10-11-2017%20(1).pdf) on October 4, 2018.

27. Bloomberg, June 24, 2018. "Amazon-Berkshire-JPMorgan Health Venture Takes Aim at Middlemen," by Zachary Tracer. Accessed at <https://www.bloomberg.com/news/articles/2018-06-24/amazon-berkshire-jpmorgan-health-venture-takes-aim-at-middlemen> on October 4, 2018.
28. Global Impact Investing Network, June 6, 2018. "Annual Impact Investor Survey 2018." Accessed at <https://theiin.org/research/publication/annualsurvey2018> on October 4, 2018.
29. Financial Times, October 2, 2018. "Miners turn to green power options," by Henry Sanderson. Accessed at <https://www.ft.com/content/b3b7fe4a-a5fc-11e8-a1b6-f368d365bf0e> on October 31, 2018.
30. Rio Tinto, March 1, 2018. "Energy and climate change." Accessed at <https://www.riotinto.com/ourcommitment/energy-and-climate-change-24291.aspx> on October 31, 2018.
31. Reuters, October 30, 2017. "Chile's Antofagasta moves to renewable energy—CEO," by Dave Sherwood, Fabian Cambero. Accessed at <https://www.reuters.com/article/antofagasta-chile/chiles-antofagasta-moves-to-renewable-energy-ceo-idUSL2N-1N11R6> on October 31, 2018.
32. Mining.com, July 10, 2018. "Antofagasta announces first mine to use 100% renewable energy," by Natalie Latuszek. Accessed at <http://www.mining.com/antofagasta-announces-first-mine-use-100-renewable-energy/> on October 31, 2018.
33. Deloitte, 2016. "The bottom line: Driving value through energy management in mining." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-the-bottom-line.pdf> on October 31, 2018.
34. CDP, July 19, 2017. "World's mining heavyweights put \$16 billion at risk in climate costs." Accessed at <https://www.cdp.net/en/articles/investor/press-release-worlds-mining-heavyweights-put-16-billion-at-risk-in-climate-costs> on November 1, 2018.
35. Goldcorp, January 29, 2018. "Goldcorp and FLSmidth win mining award for EcoTails." Accessed at <https://blog.goldcorp.com/2018/01/29/goldcorp-and-flsmidth-win-mining-award-for-ecotails/> on November 1, 2018.
36. Reuters, June 21, 2018. "First new all-electric mine dumps diesel; cuts costs, pollution," by Susan Taylor, Barbara Lewis. Accessed at <https://www.reuters.com/article/us-mining-electric-goldcorp/first-new-all-electric-mine-dumps-diesel-cuts-costs-pollution-idUSKBN1JH2FI> on November 1, 2018.
37. AngloAmerican, September 20, 2018. "Fibre optics: Mining's unsung hero." Accessed at <https://www.angloamerican.com/futuresmart/our-industry/technology/fibre-optics-minings-unsung-hero> on November 1, 2018.
38. Deloitte, 2018. "Mining capital projects." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/er-mining-capital-projects.pdf> on October 24, 2018.
39. Deloitte, 2018. "Mining capital projects." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/er-mining-capital-projects.pdf> on October 24, 2018.
40. Deloitte, 2018. "Mining capital projects." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/er-mining-capital-projects.pdf> on October 24, 2018.
41. Deloitte, 2018. "Mining capital projects." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/er-mining-capital-projects.pdf> on October 24, 2018.
42. CIM Magazine, May 17, 2018. "How do we fill the skills gap?" by Cecilia Keating. Accessed at <http://magazine.cim.org/en/management/how-do-we-fill-the-skills-gap-en/> on October 22, 2018.
43. The West Australian, May 25, 2018. "Pressure rises for WA mining sector amid dramatic fall in skilled workers," by Stuart McKinnon. Accessed at <https://thewest.com.au/business/pressure-rises-for-mining-sector-amid-dramatic-fall-in-skilled-workers-ng-b88847015z> on October 22, 2018.
44. The Australian, August 29, 2018. "Miners warn of skills crunch as student uni enrolment plunges," by Matt Chambers. Accessed at <https://www.theaustralian.com.au/business/mining-energy/miners-warn-of-skills-crunch-as-student-uni-enrolment-plunges/news-story/1eabade460ed5db0cf-1488744395d814?csp=72a152cdc32bf141e30f66c6f3061875> on October 22, 2018.
45. CIO.RU, May 21, 2018. "Gamificatoin in Norilsk Nickel: Coins for Innovation," by Nikolay Smirnov. Accessed at <https://www.cio.ru/articles/210518-Geymfikatsiya-v-Nornikele-monety-za-innovatsii> on October 22, 2018.
46. <https://www.bhp.com/our-approach/think-big> Accessed October 22, 2018.
47. Deloitte Insights. "The rise of the social enterprise: 2018 Deloitte Global Human Capital Trends." Accessed at [https://www2.deloitte.com/content/dam/insights/us/articles/HC-Trends2018/2018-HCTrends\\_Rise-of-the-social-enterprise.pdf](https://www2.deloitte.com/content/dam/insights/us/articles/HC-Trends2018/2018-HCTrends_Rise-of-the-social-enterprise.pdf) on October 22, 2018.
48. Mining.com, August 8, 2018. "Humiliated for years, women are fighting back in Chile's mines." Accessed at <http://www.mining.com/web/humiliated-years-women-fighting-back-chiles-mines/> on October 9, 2018.
49. BHP. "Inclusion and diversity." Accessed at <https://www.bhp.com/our-approach/work-with-us/inclusion-and-diversity> on October 9, 2018.
50. Freeport-McMoRan. "Sustainability; Diversity." Accessed at <https://www.fx.com/sustainability/workforce> on October 9, 2018.
51. South32. Annual Report 2018. Accessed at [https://www.south32.net/docs/default-source/exchange-releases/annual-report-2018.pdf?sfvrsn=624522bf\\_2](https://www.south32.net/docs/default-source/exchange-releases/annual-report-2018.pdf?sfvrsn=624522bf_2) on October 9, 2018.
52. The Wall Street Journal, December 8, 2017. "Mine the Gap: More Women Embrace Mining Careers," by Rachel Pannett. Accessed at <https://www.wsj.com/articles/mine-the-gap-more-women-embrace-mining-careers-1512729000> on October 9, 2018.
53. The Wall Street Journal, December 8, 2017. "Mine the Gap: More Women Embrace Mining Careers," by Rachel Pannett. Accessed at <https://www.wsj.com/articles/mine-the-gap-more-women-embrace-mining-careers-1512729000> on October 9, 2018.
54. The Wall Street Journal, December 8, 2017. "Mine the Gap: More Women Embrace Mining Careers," by Rachel Pannett. Accessed at <https://www.wsj.com/articles/mine-the-gap-more-women-embrace-mining-careers-1512729000> on October 9, 2018.

# Endnotes

55. Bloomberg, October 20, 2016. "World's Top Miner Wants to Hire 21,000 Women," by Ann Koh and David Stringer. Accessed at <https://www.bloomberg.com/news/articles/2016-10-20/wanted-21-000-women-to-meet-gender-target-at-world-s-top-miner> on October 9, 2018.
56. Fortescue Metals. "Creating Opportunities." Accessed at <http://www.fmg.com.au/workingresponsibly/creating-positive-social-change/creating-opportunities> on October 9, 2018.
57. Mining.com, August 8, 2018. "Humiliated for years, women are fighting back in Chile's mines." Accessed at <http://www.mining.com/web/humiliated-years-women-fighting-back-chiles-mines/> on October 9, 2018.
58. International Woman in Mining <https://internationalwim.org/> Accessed, October 2 2018.
59. Woman on the Move <https://womenonthemove.club/> Accessed October 2, 2018.
60. NissanNews, April 23, 2018. "Strong Nissan LEAF sales drive global EV momentum." Accessed at <https://nissannews.com/en-US/nissan/usa/releases/strong-nissan-leaf-sales-drive-global-ev-momentum> on October 29, 2018.
61. Detroit Free Press, June 12, 2018. "GM plans expanded Bolt production, 20 new electric vehicles by 2023," by Jamie L. LaReau. Accessed at <https://www.freep.com/story/money/cars/general-motors/2018/06/12/gm-plans-expanded-bolt-production-20-new-electric-vehicles-2023/685108002/> on October 29, 2018.
62. Daimler. "Plans for more than ten different all-electric vehicles by 2022: All systems are go." Accessed at <https://media.daimler.com/marsMediaSite/en/instance/ko/Plans-for-more-than-ten-different-all-electric-vehicles-by-2022-All-systems-are-go.xhtml?oid=29779739> on October 29, 2018.
63. Electrek, September 18, 2018. "VW unveils MEB platform for electric vehicles, launches 'Electric for all' campaign to have 'affordable' EVs," by Fred Lambert. Accessed at <https://electrek.co/2018/09/18/vw-meb-platform-electric-for-all-affordable-evs/> on October 29, 2018.
64. Electrek, September 15, 2018. "BMW unveils its iNEXT next-gen electric crossover concept, describes it as 'building block for the future'," by Fred Lambert. Accessed at <https://electrek.co/2018/09/15/bmw-inext-electric-crossover-concept/> on October 29, 2018.
65. Mining.com, April 12, 2018. "Impact of electric cars in medium-term copper demand 'overrated', experts say," by Cecilia Jamasmie. Accessed at <http://www.mining.com/impact-electric-cars-medium-term-copper-demand-overrated-experts-say/> on October 29, 2018.
66. PR Newswire, October 23, 2017. "Massive Graphite Shortage Looms Over Electric Car Future." Accessed at <https://www.prnewswire.com/news-releases/massive-graphite-shortage-looms-over-electric-car-future-652471503.html> on October 29, 2018.
67. Wood Mackenzie, September 25, 2018. "The rise of electric vehicles and the cobalt conundrum," by Gavin Montgomery. Accessed at <https://www.woodmac.com/news/editorial/the-cobalt-conundrum/> on October 29, 2018; Inside EVs, September 17, 2018. "Electric vehicle sales in Asia-Pacific and Europe will lead the growth," by Wade Malone. Accessed at <https://insideevs.com/ev-lithium-demand-double-by-2022/> on October 29, 2018.
68. China Daily, June 5, 2018. "Hydrogen on track to drive China's development," by Wang Keju. Accessed at [http://www.chinadaily.com.cn/a/201806/05/WS5b15ddf4a31001b82571e211\\_2.html](http://www.chinadaily.com.cn/a/201806/05/WS5b15ddf4a31001b82571e211_2.html) on October 29, 2018.
69. Anglo American, July 17, 2018. "Anglo American Platinum Commits to Venture Capital Funds Focused on Increasing Demand for PGMS." Accessed at <https://www.angloamerican.com/media/press-releases/2018/17-07-2018> on October 29, 2018.
70. Global Risk Insights, October 5, 2018. "DRC Cobalt: A potential Achilles heel of electric vehicles," by Michael Schwartz. Accessed at <https://globalriskinsights.com/2018/10/drc-cobalt-a-potential-achilles-heel-of-electric-vehicles/> on October 29, 2018.
71. Fortune, March 3, 2017. "Child Labor Revelation Prompts Apple to Make Supplier Policy Change," by Don Reisinger. Accessed at <http://fortune.com/2017/03/03/apple-cobalt-child-labor/> on October 30, 2018.
72. Coin Telegraph, May 10, 2018. "De Beers Tracks Diamonds With Blockchain For The First Time," by Aaron Wood. Accessed at <https://cointelegraph.com/news/de-beers-tracks-diamonds-with-blockchain-for-the-first-time> on October 29, 2018.
73. PR Newswire, September 4, 2018. "Peer Ledger and PAMP Announce a Comprehensive and Inclusive Solution for Optimal Management of Global Supply Chain Risks." Accessed at <https://www.prnewswire.com/news-releases/peer-ledger-and-pamp-announce-a-comprehensive-and-inclusive-solution-for-optimal-management-of-global-supply-chain-risks-300706213.html> on October 29, 2018.



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