

An aerial photograph of a large-scale mining operation. The scene is dominated by dark, textured earth with numerous tire tracks. In the center, a large, complex piece of yellow and black machinery, likely a conveyor system or processing plant, is the focal point. To the right, a long conveyor belt extends across the site. In the foreground, a series of rectangular, open-topped containers or bins are lined up. The overall atmosphere is industrial and busy.

BDO'S ENERGY 2020 VISION: THE NEAR FUTURE OF MINING

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EXECUTIVE SUMMARY



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“We expect renewables to account for one-quarter of the world’s electricity generation by 2020.”

Driverless technology, deep-sea excavations and mining expeditions on the moon were once just the ideas of sci-fi movies.

Today, they’re realities or just around the corner. And by 2020, we expect (most of) them to be the norm.

As low commodity prices persist, mining companies are under pressure to reimagine their business models. Those that have incorporated technology into their operations have seen their revenue streams live on, while those that haven’t have fallen short.

Mining is in the early stages of the Fourth Industrial Revolution, or Industry 4.0, and further digitisation is on the horizon. The value of harnessing technology is obvious. Driverless technology increases mining output by 15 to 20 percent while cutting fuel and maintenance costs by 10 to 15 percent and 8 percent, respectively. It also improves mining safety exponentially. At the same time though, these Internet-connected technologies open the mining industry up to new cyberattack vectors that they must hedge against through proper

internal controls. If not, they risk seeing their entire operation crippled by a single attack.

Decreased coal consumption in China—the world’s largest coal consumer—meanwhile, is slowing global demand for the commodity. As dependence on coal wanes, we expect renewables to account for one-quarter of the world’s electricity generation by 2020.

Reflecting on this period of transition, BDO’s Global Natural Resources team is looking towards the future to help mining companies anticipate and plan for the challenges and opportunities ahead. We believe that to prepare for success in 2020 and beyond, mining companies must strive to become “Lean, Green, Digital” machines.

The global predictions presented in this report are based on research and collective input from BDO’s Natural Resources and Mining leaders. In addition, the practice leaders from five countries (Australia, Canada, South Africa, the United Kingdom, and the United States) have provided predictions for the industry in their local markets.

SUMMARISING BDO’S ENERGY 2020 VISION FOR MINING:

1. ROBOTS:

By 2020, robots will replace more than 50 percent of miners, and mining accidents will be cut by 75 percent. Half of the miners will themselves be retrained to run the technology controlling the robots.

2. EU CONFLICT MINERALS:

Supply chain transparency will take the compliance spotlight for 2020 as companies gear up for the European Union’s Conflict Minerals Rule, effective in 2021.

3. CYBERSECURITY:

By 2020, activist hackers will launch at least five cyberattacks on mines around the world in Permanent Denial of Service (PDoS) attacks aimed at eliminating the environmental and social threats they pose. They’ll use workers’ connected devices to initiate the attacks.

4. RENEWABLES:

By 2020, renewables will account for one-quarter of the world’s electricity generation as dependence on coal wanes.

5. IoT IN MINING:

Global mining companies leveraging Internet-connected sensors and automated drillers in mines will decrease their per ton digging costs by more than 30 percent.

Agree or disagree with our predictions? We want to know—reach out to us [here](#).

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BDO'S ENERGY 2020 VISION: THE NEAR FUTURE OF MINING GLOBAL PREDICTIONS



WHEN ROBOTS RUN THE MINES

PREDICTION 1

ROBOTS

BY 2020, ROBOTS WILL REPLACE MORE THAN 50 PERCENT OF MINERS, AND MINING ACCIDENTS WILL BE CUT BY 75 PERCENT. HALF OF THE MINERS WILL THEMSELVES BE RETRAINED TO RUN THE TECHNOLOGY CONTROLLING THE ROBOTS.

Robots will be at the forefront of most mineral extraction by 2020, reducing safety risks for miners, maximising output, and streamlining costs. By 2020, we predict robots will replace most miners. Most in the workforce will be retained, but advances in technology and remote mining equipment will transform what that workforce looks like.

The global mining industry is already well-acquainted with autonomous technology. Self-driving trucks and autonomous drillers and muckers are employed onsite at almost every large multinational company's mines. "Snake robots"—named for their agility—are equipped with Internet-connected sensors and used to navigate narrow mine shafts and collect data. Drones are also beginning to play a role in mapping the topography of a mine and capturing aerial images of inaccessible areas of the mine to identify possible vulnerabilities and areas of tension. Remote vein miners (RVMs) are being developed to eliminate the need to drill and blast to excavate rock—potentially reducing rock stress that can lead to seismic events.

The rise of the robot is not a death knell for the mining workforce but will inevitably lead to a demand for reskilling. Traditional operational positions—drilling, blasting, and driving—will be downsized, but replaced by demand for remote operators and maintenance personnel to create the new version of the miner. Emerging digital mining jobs—engineers, software developers, and data processing and data analytics specialists—are more likely to attract the technologically savvy millennial workforce. By 2020, mining automation and data analytics will be key components of the curriculum for mining engineers.

Digitisation also promises to reduce safety risks for miners. Not only will robots assume the most dangerous tasks, but they'll also be key to minimising damage if disaster strikes. Snake robots and the smart sensors they're equipped with will be further optimised to capture real-time data to predict or quickly identify equipment malfunctions and closely track miners' exact locations and vitals. With the aid of robots and new technology, the number of mining fatalities will be cut in half by 2020.

Mining is in the early stages of the Fourth Industrial Revolution, or Industry 4.0, and further digitisation is just around the corner.



TRANSPARENCY COMBATS CONFLICT

PREDICTION 2

EU CONFLICT MINERALS RULE

SUPPLY CHAIN TRANSPARENCY WILL TAKE THE COMPLIANCE SPOTLIGHT FOR 2020 AS COMPANIES GEAR UP FOR THE EUROPEAN UNION'S (EU) CONFLICT MINERALS RULE, EFFECTIVE IN 2021.

The EU's efforts to stem trade in minerals that finance armed conflicts and terror groups will turn a spotlight on global mining companies' supply chains by 2020.

The EU's Conflict Minerals Regulation, effective in 2021, establishes supply chain due diligence for imports of tin, tantalum, tungsten, and gold (3TG)—used to produce phones, cars, and jewellery. The rule aims to ensure European industries use responsibly-sourced minerals, stemming proceeds that finance armed conflict in high-risk areas.

What the rule means for the mining industry:

- EU-based 3TG importers and their international supply chain partners—smelters and refiners—will need to update their supply chain due diligence
- Additionally, 3TG importers in the EU will need to identify the smelters and refiners in their supply chains, confirm their due diligence practices comply, and report insufficient supply chain due diligence

- The Organisation for Economic Co-Operation and Development (OECD) laid out a five-step framework for the due diligence requirements:
 - Create strong company management systems
 - Identify and assess supply chain risk
 - Implement a program to respond to such risks
 - Conduct an independent third-party audit of supply chain due diligence
 - Submit annual reports on supply chain due diligence.

All upstream companies are subject to the due diligence requirements when they import—the riskiest area of the supply chain—as are downstream companies that import metal-stage products. This regulation will likely create a lowest common denominator effect across the global mining industry—for EU-based 3TG importers and their international supply chain partners—requiring the entire industry to put supply chain due diligence at the forefront.





HACKTIVISTS TARGET MINES

PREDICTION 3

CYBERSECURITY

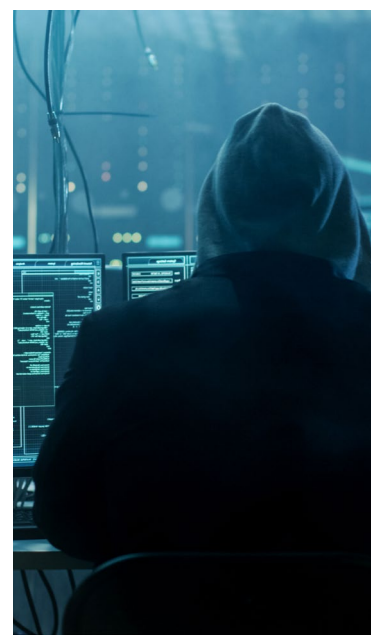
BY 2020, ACTIVIST HACKERS WILL LAUNCH AT LEAST FIVE CYBERATTACKS ON MINES AROUND THE WORLD IN PERMANENT DENIAL OF SERVICE (PDoS) ATTACKS AIMED AT ELIMINATING THE ENVIRONMENTAL AND SOCIAL THREATS THEY POSE. THEY'LL USE WORKERS' CONNECTED DEVICES TO LAUNCH THE ATTACKS.

The mining industry is no stranger to [environmental scrutiny](#). Advances in technology have introduced more sustainable mining methods, including the emerging practice of bioleaching, in which companies extract minerals by using biological assets instead of harmful chemicals. Despite those advancements, environmental concerns persist, including water and soil contamination, carbon emissions, and impact on animal life. Pressure from environmentalists is set to increase by 2020. In fact, an emerging type of environmentalist—activist hackers (hacktivists)—will soon have their targets locked on the mining industry. By 2020, there will be at least five Permanent Denial of Service (PDoS) cyberattacks on mines around the world, motivated by eliminating the environmental and social threats they pose.

PDoS attacks are the next generation of Distributed Denial of Service (DDoS) attacks—which temporarily disable operations—and aim for permanent destruction. In a PDoS attack, hackers' goals include destroying physical equipment and structures, disabling services, and/or wiping out data. For global mining companies in the early stages of harnessing big data, losing seismic and reserves data would be damaging to their ongoing operations.

While the rapid acceleration and adoption of new technology will be instrumental in bolstering mining's future, it will also be the sector's Achilles heel when it comes to cybersecurity. The industrial control system, the central hub controlling a mine's automated operations, could serve as the hacker's point of entry into the mine's remote

operating controllers and connected devices. Damage and disruption to automated equipment could also jeopardise the safety of workers in the mines—as many of the systems in place are designed to monitor and detect dangerous conditions.



COAL STRIPPED OF SOME POWER

PREDICTION 4

RENEWABLES

BY 2020, RENEWABLES WILL ACCOUNT FOR ONE-QUARTER OF THE WORLD'S ELECTRICITY GENERATION AS DEPENDENCE ON COAL WANES.

Decreased coal consumption in China—the world's largest coal consumer—is slowing global demand for the commodity. According to the International Energy Agency, global coal consumption decreased about 2 percent last year. In confluence with the rapid growth of renewables, the world's energy mix is set for a [shakeup](#). By 2020, we predict that renewables will grow to account for one-quarter of the world's electricity generation as dependence on coal wanes.

Mining plays an integral behind-the-scenes role in developing renewable energy. Electric vehicles, wind turbines, and solar panels rely on minerals like aluminium, copper, lithium, and various emerging, rare metals. Powered by new technology, deep-sea mining is allowing mining companies to tap into previously inaccessible reserves of copper, nickel, and cobalt, among others, beneath the ocean floor to fuel increased demand for these minerals.

In 2019, Nautilus Minerals, a Canadian mining firm, is set to launch one of the first large deep-sea mining ventures in the Bismarck Sea with the aid of remote-controlled robots. The excursion is forecast to produce more than [72,500 metric tons of copper](#) and more than 4.5 metric tons of gold. The International Seabed Authority, a United Nations regulatory body, has granted 25 contracts to nations including China, India, Japan, and Brazil to embark on similar deep-sea mining projects.

By 2020, further advancements will be made to overcome one of renewables' largest hurdles: energy storage. The world's largest lithium ion battery—built by Elon Musk in November 2017—is a 100-milliwatt (MW) battery storage farm located in Australia. Come 2020, the capacity of energy storage is likely to evolve well beyond 100MW, solidifying renewables' role in the world's energy mix.





AN ARSENAL OF AUTOMATION BOOSTS PROFITABILITY

PREDICTION 5

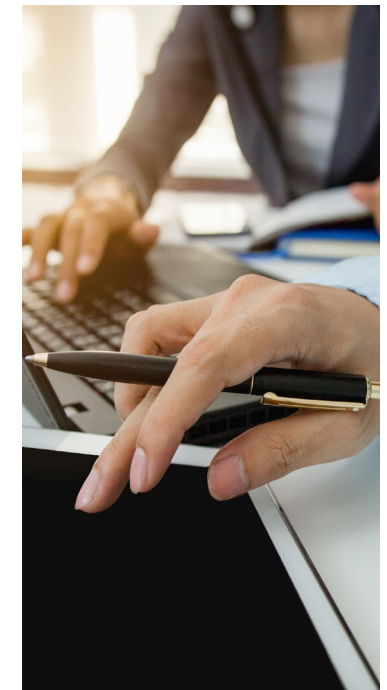
IOT IN MINING

GLOBAL MINING COMPANIES LEVERAGING INTERNET-CONNECTED SENSORS AND AUTOMATED DRILLERS IN MINES WILL DECREASE THEIR PER TON DIGGING COSTS BY MORE THAN 30 PERCENT.

In an environment of subdued commodity prices, the value of harnessing technology is clear. Mining companies' end consumers closely monitor the price of commodities and are sensitive to the slightest uptick. For automakers, for example, steel is a significant expense on their books. When multiplied by a few thousand metric tons, a variance of a few cents on steel price could incentivise automakers to find a new supplier. Global demand is not expected to wane. In fact, steel and mining company ArcelorMittal [forecasts](#) a 36 percent increase to automakers' global demand for steel by 2020. However, which global mining companies win that business is up for debate.

Tapping into [new technology](#) is key to streamlining operations, reducing expenditure, and enabling companies to keep their prices competitive. The [International Institute for Sustainable Development](#) estimates driverless technology, for instance, increases mining output by 15 to 20 percent, while decreasing fuel and maintenance costs by 10 to 15 percent and 8 percent, respectively. Self-driving trucks are just the tip of the iceberg. Global mining companies that digitise nearly all their drilling—relying on a combination of automated drillers and Internet-connected sensors—will recognise far more significant savings. By 2020, we predict global mining companies' per ton digging costs will decrease by more than 30 percent because of automation.

These savings factor in reduced labour costs, increased output, a decrease in the number of safety incidents, and companies' ability to enhance decision-making capabilities leveraging the vast amount of data collected by smart mines.



BDO'S ENERGY 2020 VISION: THE NEAR FUTURE OF MINING IN AUSTRALIA



ARTIFICIAL INTELLIGENCE AND PRICE NEGOTIATION

PREDICTION 1

ARTIFICIAL INTELLIGENCE

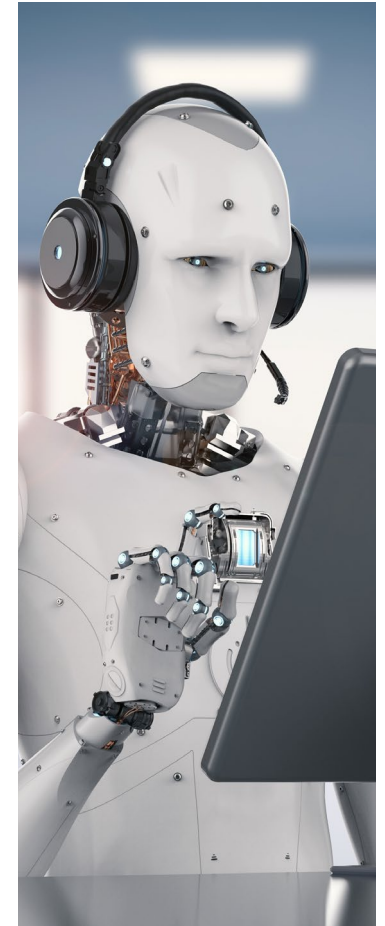
BY 2020, ARTIFICIAL INTELLIGENCE (AI) WILL CHANGE THE WAY WE NEGOTIATE AND PRICE CONTRACTS, AND HUMANS WILL NO LONGER CONTROL DEALS IN MARKETS.

If you want to know where the mining industry is headed, look to AI.

With the rapid advancement in technology, AI systems are becoming the way of the future for most industries—and mining is no different. As mining companies embrace technologies that have significantly improved efficiencies and processes at all stages of the mining lifecycle, we expect that commodity supply negotiations will no longer require human interaction.

AI technology will drive computerised negotiation, providing benefits of reduced time, cost, and cognitive effort in negotiating win-win deals. The Extractive Industries Transparency Initiative (EITI) is a global standard to promote the open and accountable management of oil, gas, and mineral resources. Such initiatives have been fuelling the need for greater transparency in the natural resources sector, with an end goal of creating deals that are managed effectively for increased development impact.

AI-based negotiations will enable higher quality agreements that are economically and socially beneficial, driving economic growth and social development. Human interaction will play a greatly reduced role in the negotiation process, ultimately changing the way contracts are priced. These negotiations will rely on key information including licencing, ownership, legal and financial arrangements, production levels, and allocation of revenue to determine efficient and ethical negotiation outcomes for all parties. This is particularly relevant in the Asian region where a number of marketing hubs are located. In addition, a number of miners in the region operate projects with commodities that have opaque pricing.



MINERS OF THE FUTURE

PREDICTION 2

TECH INNOVATIONS

BY 2020, TECH COMPANIES WILL BECOME THE MINERS OF THE FUTURE.

Could Apple or Tesla be the mining companies of the future?

Just as AI will replace today's price negotiation process, technology companies will revolutionise the miners of the future. Technology companies have been "mining" more and more over the last few years—but in respect to data and Bitcoin. By 2020, however, they may well become traditional miners.

Technology companies have become some of the world's largest by market capitalisation, and their rapid growth is likely to continue. Two crucial factors may present some challenges and impede the rate at which these companies expand. The first is anti-trust or competition, potentially limiting their ability to expand horizontally into their existing markets. Secondly, technology innovators are heavily reliant on the security of resources, and we will see them seek to secure the supply of rare materials. Because of these two factors, we are likely to see technology companies undertake meaningful ownership stakes in mining companies—or even buy the mines themselves.

Competition will put pressure on cash-rich companies that find it relatively easy to raise funds, making it difficult for them to make acquisitions in their existing markets. These companies will most likely look to other markets for vertical integration, rather than returning that cash to shareholders.

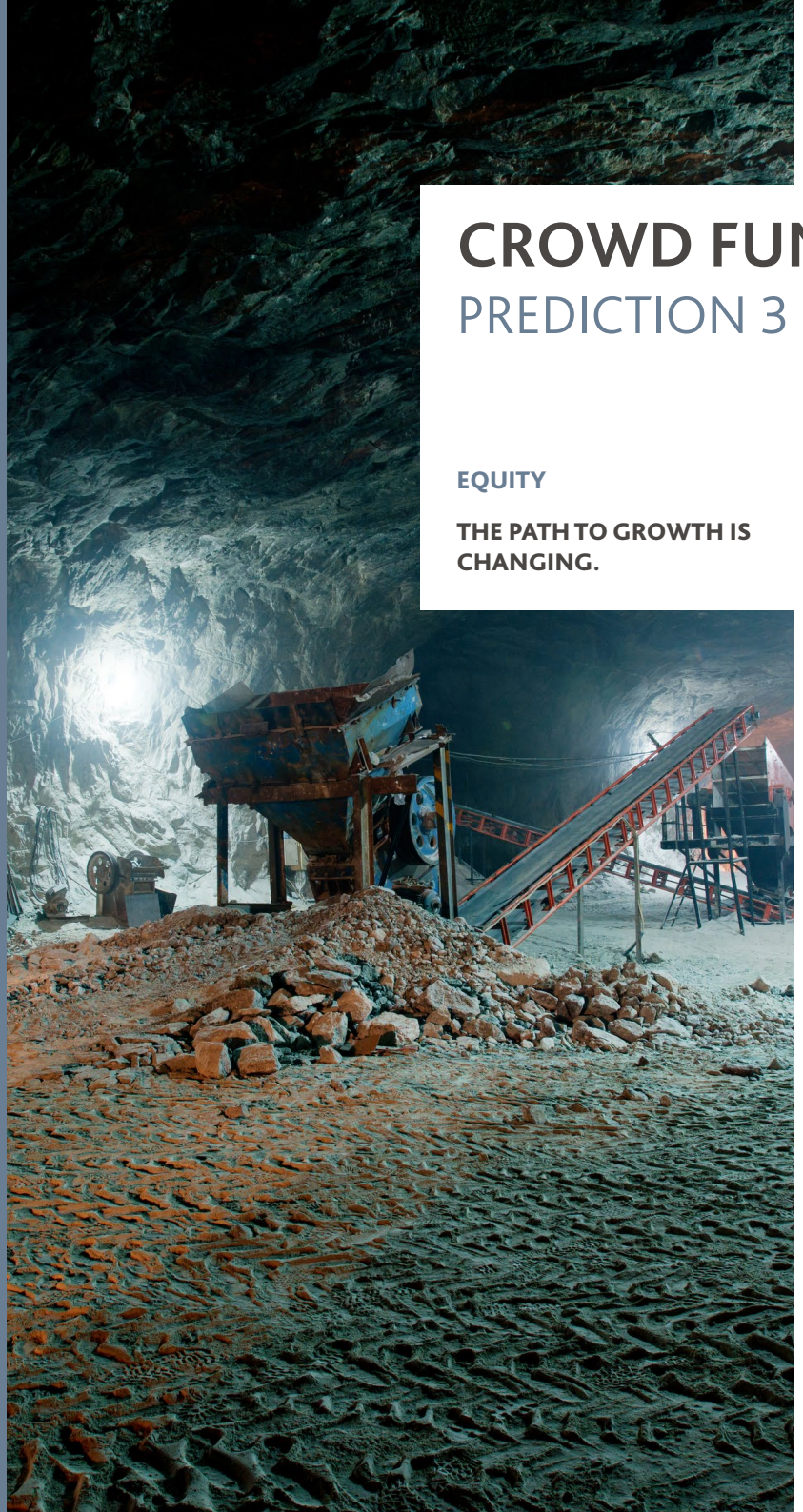
Technology companies rely on commodities to manufacture their high-tech products, particularly high-demand ones such as battery minerals (lithium, cobalt, graphite, etc.) or those in short supply (rare earths, tungsten, etc.). With a considerable stake in the game, technology companies will likely step in to maintain a strong mineral supply. Projects that are likely to be acquisition targets will be located in jurisdictions such as Australia where there are well-established legal frameworks to provide security of tenure.



CROWD FUNDED PREDICTION 3

EQUITY

THE PATH TO GROWTH IS CHANGING.



For decades, most Australian mining companies have followed a well-worn growth path. The journey has historically started with an exploration area privately funded by friends and family. Following additional rounds of raising capital at the exploration stage, successful companies will require larger amounts to allow for necessary feasibility studies to be undertaken, enabling the large-scale funding required to build the mine. To get the funding, they typically progress to an early small-scale Initial Public Offering (IPO) on the Australian Securities Exchange (ASX).

This initial public funding has allowed them to raise a few million dollars—enabling exploration to continue. As a result, many small exploration companies are subject to the same reporting and disclosure requirements as all other ASX-listed companies, presenting a significant burden on small-listed explorers compared to large-listed companies.

Crowd Sourced Equity Funding (CSEF) legislation was passed by the Australian Government in 2017 and CSEF platforms will be live in 2018. While the media focus on CSEF has been on technology start-ups, the new method of financing in Australia has the potential to transform the growth path of small-to-medium mining companies as well. CSEF will likely replace the first rungs of the ASX ladder for exploration companies.

By 2020, rather than planning for the obligatory IPO on the ASX, the managing director of an exploration company will plan for a crowdfunding offer on a CSEF platform. The company will raise the funds it needs without the burdens of being an ASX-listed company, and with reduced compliance requirements. This will allow for a greater focus of efforts and resources into exploration and value-add activities.

If the company experiences exploration success with the funds raised, it will be better placed to seek an ASX listing—and better able to cope with the associated burdens. By 2020, we see CSEF forming a key part of the growth journey for exploration companies, with early ASX listing becoming a strategy of the past.

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BDO'S ENERGY 2020 VISION: THE NEAR FUTURE OF MINING IN CANADA



DIGITAL: NO LONGER A BUZZ TERM

PREDICTION 1

MINING DIGITIZATION

BY 2020, "DIGITAL" WILL NO LONGER BE A BUZZ TERM, AND BLOCKCHAIN WILL BECOME A NECESSITY.

Digitization may not necessarily be new to mining, but the industry is just now figuring out how to get the most out of it.

Companies like Goldcorp, CISCO, AWS, Microsoft, and Barrick Gold have sponsored numerous developer hackathons in recent years. The sector has seen multiple waves of digital transformation since the 1950s—from computer simulations to modern GPS-controlled heavy haulers. But how much has the industry benefited from previous digital waves, and how much will it benefit from the latest wave?

We see [blockchain](#) as the next wave—becoming a necessity to Canadian mining companies by 2020. Think of blockchain as a version of the Internet that can carry out various transactions but is virtually impossible to hack. It has the potential to revolutionize financial services by making transactions cheaper, quicker, and more transparent and trustworthy. [Blockchain in 2020](#) will change the mining and metals industry in Canada by lowering costs in mid and back offices.



DIVERSIFYING THE WORKFORCE

PREDICTION 2

EXPANDED LABOR FORCE

BY 2020, NEW AND RECENT IMMIGRANTS, ABORIGINALS, AND WOMEN WILL CONTINUE TO MAKE UP THE PERSONNEL SHORTFALL IN CANADA'S GROWING MINING SECTOR.

The mining industry, both in Canada and abroad, faces many human resources challenges. We see diversification as the answer.

Competition for skilled workers is fierce both within Canada and globally. In fact, companies in other countries are actively recruiting Canadian graduates and workers, making retention challenging and recruitment highly competitive. According to [Natural Resources Canada](#), the Canadian mining industry will need to hire 106,000 new workers by 2025.

At the end of 2017, in an effort to combat this problem, the [Canadian government](#) announced a 7 percent increase in its target for permanent resident admissions. Other proposed actions to address the mining workforce shortage in Canada include:

- Promoting the industry to youth, aboriginal peoples, and non-traditional worker groups
- Developing programs that bring back retired workers, retain older workers, and increase mentoring
- Improving educational programs and employer-provided training
- Introducing standards for key occupations to facilitate domestic worker mobility and skills recognition.



BITCOIN OR GOLD: THAT IS THE QUESTION

PREDICTION 3

FINANCIAL REGULATION

BY 2020, THE DEBATE OVER BITCOIN VERSUS GOLD WILL ONLY INTENSIFY AS FINANCIAL REGULATORS LOOK TO CONTROL THIS NEW MEDIUM OF EXCHANGE AND AVOID ANOTHER DOTCOM BUST.

Bitcoin or gold—that is the question for the mining industry in Canada. But the answer may be harder to come by as financial regulators seek greater control over the former.

We see several factors—including regulation, meteoric rises and falls in Bitcoin value, currency wars, crypto currency hacking, and another major recession—putting gold back in the top seat.

[Bank of Canada](#) Governor Stephen Poloz is sounding the alarm on [Bitcoin](#), calling the purchase of the cryptocurrency “closer to gambling than investing.” In a December 2017 speech Poloz said Bitcoin is an unreliable store of value and does not constitute “money.” He added that buying the cryptocurrency “means buying risk” and urged those flocking to it to “read the fine print.”



INTEGRATING SUSTAINABLE STRATEGIES ACROSS SUPPLY CHAIN

PREDICTION 4

CLEANTECH

BY 2020, 30 PERCENT OF MINING INDUSTRY LEADERS WILL HAVE DEFINED AND IMPLEMENTED PLATFORM CLEANTECH STRATEGIES.

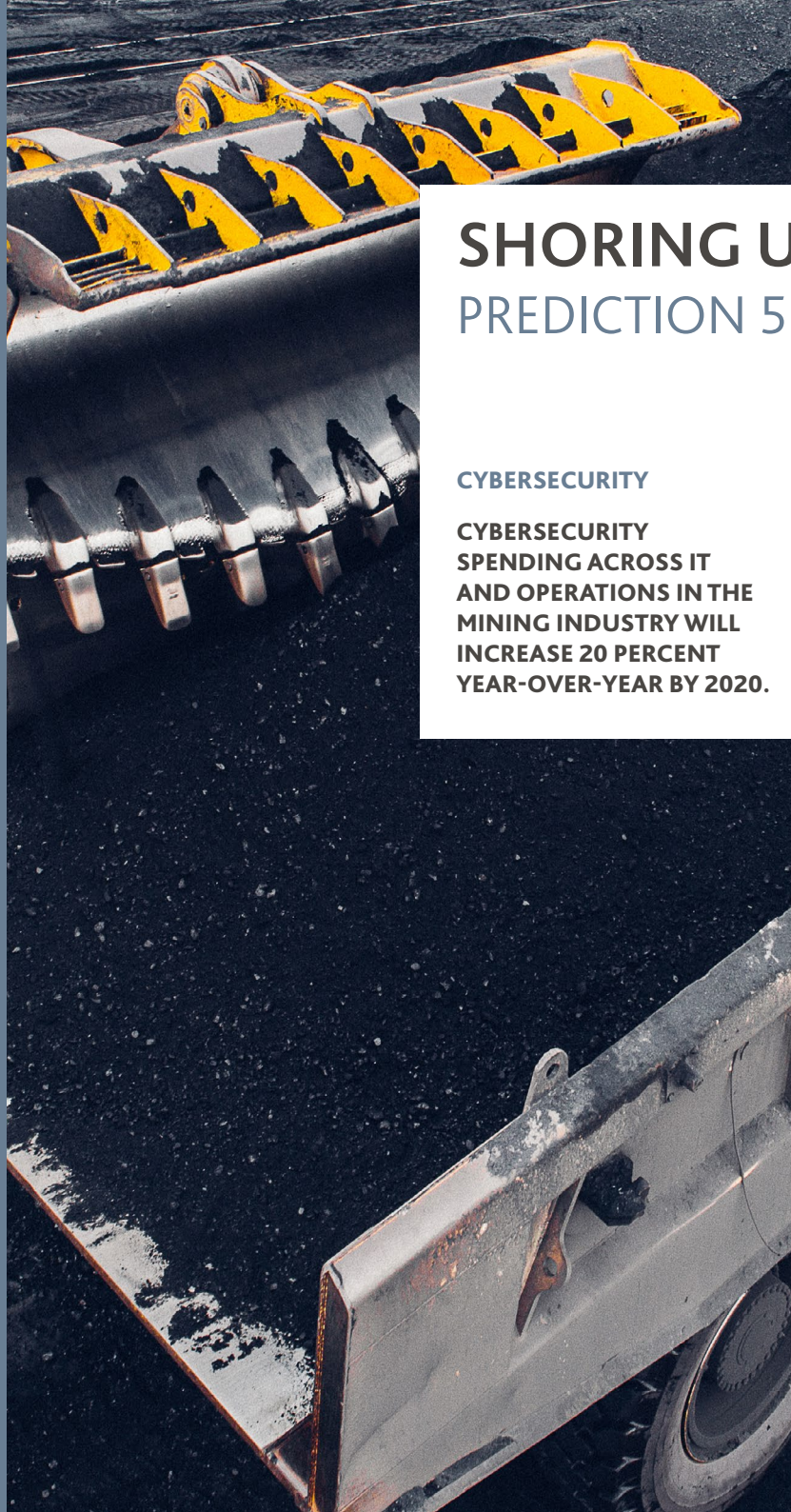
In such critical times for the mining industry, creating integrated environments across equipment, maintenance, planning and scheduling, and execution is key to addressing concerns around [climate change](#).



Driven by emerging economies, demand for mineral resources continues to rise, but mining companies are under ever-increasing pressure from governments, customers, and other stakeholders to operate in a sustainable manner. Many key [industry players in the mining sector](#) have developed energy saving strategies and are investing directly into renewable energy infrastructure. IAMGOLD, a Canadian firm, signed a \$20 million, 15-year power agreement for a solar installation at its off-grid Essakane mine in Burkina Faso. India is having a clean energy renaissance, with key mining companies joining in. Chile, meanwhile, is seeing a huge clean energy boost from its red metal mines.

In 2020, [climate change concerns](#), greenhouse gases, and regulation will continue to be top of mind and a major issue for the mining and metals sector—a major consumer of energy and primary user of land. New initiatives to combat climate change will be introduced, and there will be an escalating need for companies to respond to increased regulation of emissions.





SHORING UP SPENDING ON DEFENSE PREDICTION 5

CYBERSECURITY

CYBERSECURITY SPENDING ACROSS IT AND OPERATIONS IN THE MINING INDUSTRY WILL INCREASE 20 PERCENT YEAR-OVER-YEAR BY 2020.

The key to mitigating the cyber threat will be information sharing.

Companies like [Goldcorp](#) and a group of Canadian miners have moved to create a joint task force to increase knowledge sharing specific to the real and present cyber warfare dangers to mining assets.

[Luis Canepari](#), vice president of IT at [Goldcorp](#), sounded the alarm bell in 2017 at a Toronto security conference after hackers penetrated the company's computer network and stole troves of data including bank accounts, wire transfers, and payroll records.

"This was a real eyeopener for us and we were quite frank about what had happened and what we needed to do better," he said. "You can't wrap yourself in a cocoon. Secrecy doesn't help anyone."

Today, virtually all parts of the mining supply chain are connected to the Internet. Ventilation and conveyor systems are managed by supervisory control and data acquisition (SCADA) systems. Even new hauling trucks come with 100 wireless sensors to be used.

Cybersecurity risk mitigation plans for mining organizations should focus on:

- **Operational technology:** This function should work with information technology to make sure the architecture around remote access is well-secured.
- **Emerging technologies:** Mobile technologies, machine automation, and cloud integration are often adopted quickly, and before they can be tied into cybersecurity systems. Beware: Their ease of use can provide a window of opportunity for hackers.
- **M&A:** These generate a huge amount of confidential information. Security needs to be looped in early in the process to make sure that information is safe and both companies involved are protected.
- **Third-party management:** Different parts of the supply chain can have fewer security controls and can put the whole ecosystem at risk. Any data generated between two companies needs to be protected, shared, and stored securely.

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BDO'S ENERGY 2020 VISION: THE NEAR FUTURE OF MINING IN SOUTH AFRICA



RETHINKING LIFE OF MINE MODELS

PREDICTION 1

REGULATORY

**INCREASED
GOVERNMENTAL
REGULATIONS WILL
LEAD TO INCREASED
UNPREDICTABILITY OF LIFE
OF MINE PLANS BY 2020.**

Life of Mine (LOM) models will get a makeover by 2020.

Regulatory risk has been a feature of mining for many years, and LOM models have developed country-specific risk factors that affect the discount rates applied in the valuation models used for such purposes. This process of assessing country risk has been undertaken on a country-by-country basis and is largely driven by an assessment of the degree of political stability in a country.

We have witnessed increasing degrees of government regulation in areas that were previously assumed to be fairly stable. For example, new regulations relating to state ownership, royalties, and mining tenure in Tanzania have purported to supersede all the stability agreements that were entered into over the last 20 years. These were specifically designed to attract new investment in the mining sector in Tanzania.

Our prediction is that LOM modelling techniques will have to be refined to account for this factor via a more sophisticated approach to the historical data available and the general factors underlying this.



BREAKING BOUNDARIES FOR DEEP-LEVEL MINING

PREDICTION 2

QUICKENED DEVELOPMENT

BY 2020, DEEP-LEVEL MINING CHALLENGES WILL ACCELERATE THE DRIVE TO DEVELOP COST-EFFECTIVE ALTERNATIVES TO TRADITIONAL MINING PROCESS.

The health and safety issues associated with deep-level mining, paired with increased labour costs, will remain in the spotlight—but under a different lens.

Much has been written about mining being disrupted by digital transformation and new processes, but in this area, the degree of change, the cost of research, and the implementation of new technology is greater.

We believe that the easy wins have been achieved and are in the process of being implemented in areas such as metallurgical and stores systems. Replacing traditional drill and blast processes is in a different league and requires new solutions

We predict the drive to develop cost-effective alternatives to traditional mining processes to continue. Long-term views on the cost/benefit analysis is key to justify introduction on a larger scale. However, the sustainability of mining operations will demand changes and increased technology. We expect that innovation and investment in this area will increase, but investors will wait to commit large sums until the various prototypes have been established as cost-effective solutions.



COMMUNITY ENGAGEMENT MODELS IN THE SPOTLIGHT

PREDICTION 3

SOCIAL LICENCE TO MINE

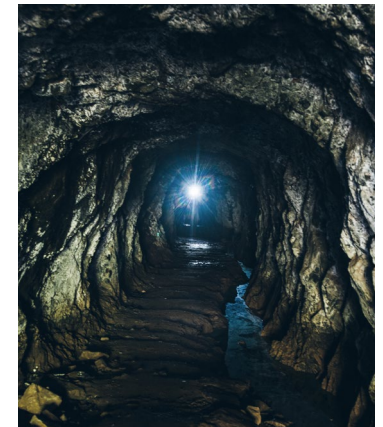
BY 2020, COMMUNITIES AROUND MINING SITES WILL HAVE A GREATER IMPACT ON COMPANY OPERATIONS THAN NATIONAL LEGISLATION.

Forget national legislation. By 2020, it will be the communities around mining operations that have the greatest say in a company's right to mine.

With growing political risk factors, governments are increasingly intervening in mining regulation, which is contributing to more unpredictable valuations of mining projects, including rehabilitation expectations. Another trend we have seen is that community engagement models are playing an increasingly important role in establishing a company's "social licence to mine". All listed mining companies have sustainability reports that measure various factors relating to their operations, their impact on local communities, and their efforts to mitigate such impacts.

We predict that these trends will continue and that even if the mining company has complied with the national legislation affecting their operations, the communities around the mining areas will increasingly demand a say in a variety of areas. Some of the important areas will be the environmental impact and whether the area will be sustainable from an agricultural point of view in the future.

Community engagement models will become a bigger area of focus in feasibility and pre-feasibility studies and will have to be more carefully managed in the future.



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BDO'S ENERGY 2020 VISION: THE NEAR FUTURE OF MINING IN THE UK



DEMISE OF OFFSHORE HOLDING COMPANIES

PREDICTION 1

TAXATION

BY 2020, WE WILL SEE THE DEMISE OF OFFSHORE HOLDING COMPANIES IN ZERO TAX JURISDICTIONS.

Many mining businesses are international groups with operations and administrative functions located in several different countries. Over the last 20 years, the use of offshore holding companies has been a common approach to achieving tax-efficient group structures. However, the landscape is now rapidly changing and by 2020, mining groups will no longer be forming new zero tax offshore holding companies.

The last two years have seen the most significant development in international tax history. The pace of the changes, led by the Organisation for Economic Co-operation and Development (OECD) and G20, has been staggering. To date, more than 100 countries have signed up to a multilateral instrument aimed—amongst other actions—to combat treaty shopping (the practice of using low or zero-rated tax regimes to minimise or eliminate withholding taxes). Political pressure will be levied on those countries that have not yet signed up to encourage widespread use of these measures.

Base erosion and profit shifting—which are strategies that exploit gaps and mismatches in tax rules to artificially shift profits to low or no-tax locations—have been at the heart of these changes following high-profile cases of multinational companies. Governments are being encouraged to adopt various measures ensuring that profits are properly taxed in the jurisdictions in which the economic activities arise. As a result, we are seeing a significant reduction in tolerance to tax risk, while tax compliance and risk strategy is escalating up the board room agenda.

The OECD measures include the introduction of country-by-country reporting (the requirement for large companies to provide transfer pricing data to its tax authority for sharing with other tax authorities). We can expect to see more collaboration between tax authorities to combat secrecy and ensure profit shifting is addressed globally.

The UK tax authorities have already adopted several measures to make the country fiscally enticing as a holding company location for the mining sector. The UK government recognises the need to remain an attractive place for talented management and mining groups to ensure it capitalises on the shift away from offshore holding regimes.

IPO RUSH

PREDICTION 2

FINANCE

LONDON MINING IPOs WILL INCREASE FOURFOLD BY 2020.



By the end of 2020, mining IPOs will make a dramatic return to the London stock exchanges. We're predicting there will be four times as many flotations as in the previous three years.

There was an increase in mining IPOs in 2017; however, they were relatively small in terms of value. Despite the slow growth of the world economy, there are strong indications that investor appetite for the right project is increasing. The relevant question is: What does the right project look like? Based on what we're seeing, a project should fulfil as many of the following criteria as possible:

- i. **Scale and quality:** Does it make economic sense as a standalone project?
- ii. **Management:** As always, you need the right blend of skills and experience to bring any project into production. Have the management team done it before, preferably with the same commodity and in the same country/region?

iii. **Cash flow and stage of development:** There is a strong preference for one-time-only fund raises to bring an asset into production. Exploration remains a challenge to fund via the public markets.

iv. **Choosing the right commodity:** Investors are looking to invest in commodities where they see near-term shortages in supply or long-term growth in demand. For example, there is high demand for commodities linked to the new technology-led economy of mobile communication and electric transportation.

v. **Political risk:** While it's never possible to eliminate political risk, some jurisdictions are going to be difficult regardless of the nature of the project.

A significant increase in new funding into the sector will drive the development of new mines to produce increasing volumes of metals needed in the next 10 years by the new low-carbon economies.



BLOCKCHAIN PROVING VALUE

PREDICTION 3

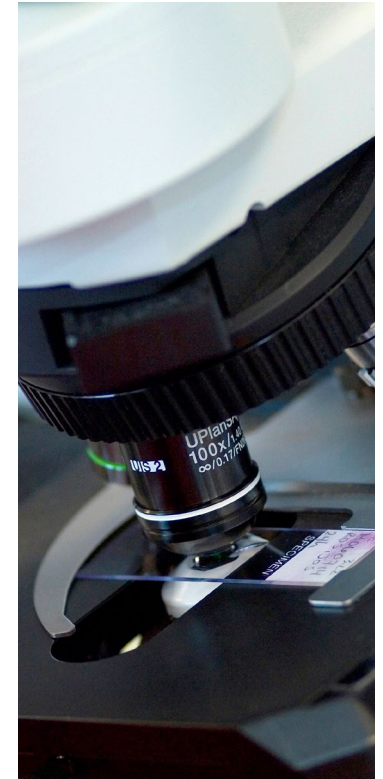
TECHNOLOGY

BLOCKCHAIN TECHNOLOGY WILL BE USED TO VERIFY THE PROVENANCE OF HIGH-VALUE MINERALS BY 2020.

For many years, the verification of the provenance of high-value gemstones has been a significant concern for the buyers of those stones. The Kimberley Process was introduced 15 years ago to help address the problems of diamonds being used to finance conflicts. New rules such as the EU's Conflict Minerals Regulation, combined with pressure from the OECD, will place more responsibility on miners to provide verification of the high-value metals they produce.

Blockchain, a technology originally developed to assist verification and transactions of Bitcoin, will form a vital part of the process. It could revolutionise the verification of the provenance of high-value minerals, providing a unique list of records that is secure from tampering and forgery. As such, it is a technology ideally suited for the identification of products throughout the supply chain.

Major diamond producers are in the advanced stages of using blockchain technology to provide each diamond with a unique imprinted code that serves as a tamper-proof record of the stone's authenticity. Over the next three years, the mining industry will start to adapt this technology for similar authentication of other high-value minerals, ensuring the required supply chain transparency to manufacturers and end users.



OUTSIDERS BECOME REGULARS

PREDICTION 4

NEW INVESTORS

NON-MINERS WILL MAKE SIGNIFICANT INVESTMENTS IN THE SECTOR BY 2020.

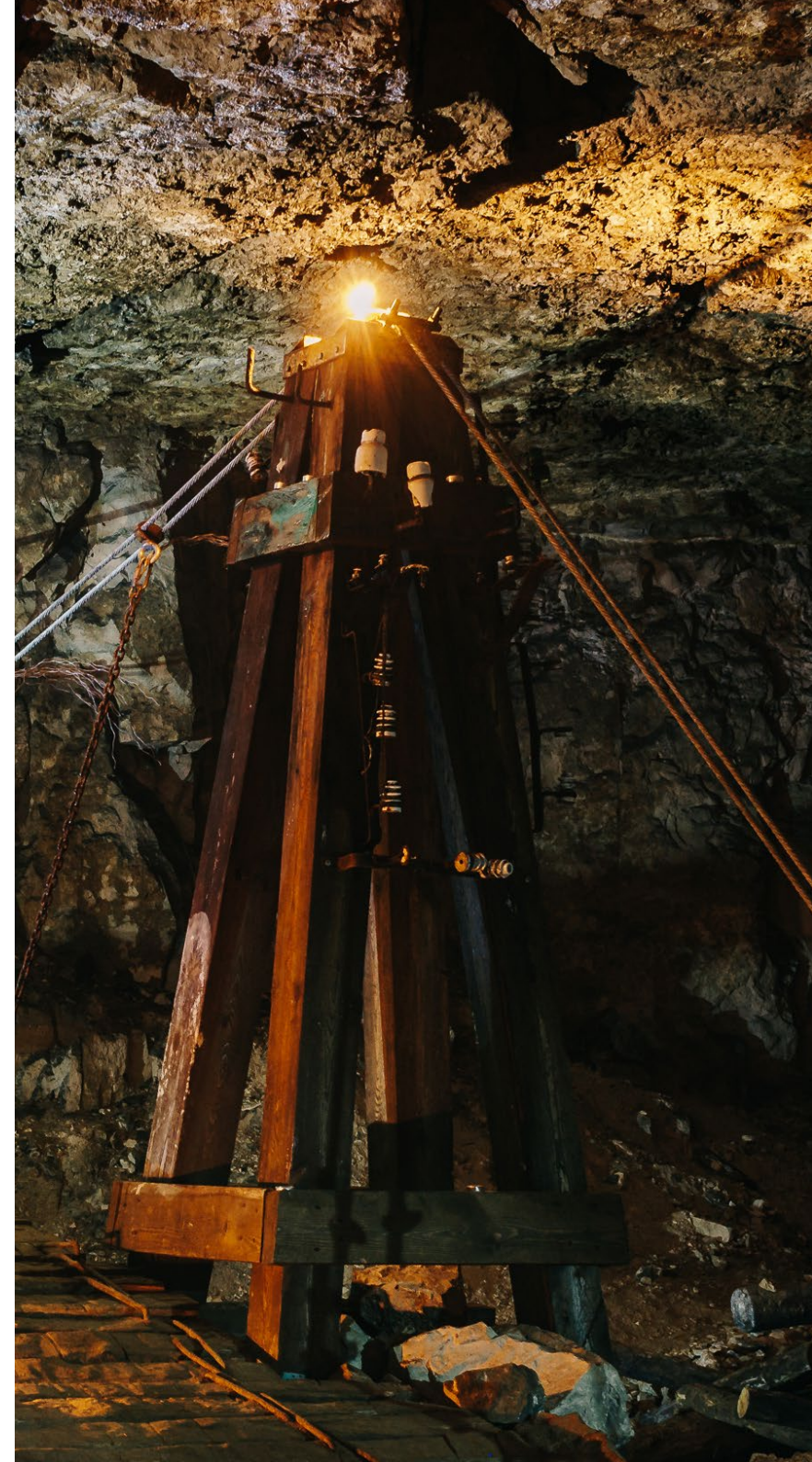


Our economies are experiencing a rapid and accelerating transition from carbon-based to renewables-powered, with a growing requirement for electrical storage and battery power in all aspects of our lives. This uptick in demand for batteries and their associated equipment will require similar increases in the production of a wide range of metals. Lithium has had the highest profile; however, modern battery technologies require other metals, including nickel, cobalt, cadmium, and magnesium.

The surge in demand for these metals will only be met by the discovery of new resources and the opening of new mines. In recent years, the big mining companies—damaged by poor financial performance and several high-profile failed projects—have been reluctant to invest in large-scale exploration. Smaller mining companies have been keen to progress new exploration projects

for these metals, but the institutional funds and private investors remain cautious about funding early-stage exploration projects, having incurred significant losses at the end of the last mining boom.

Non-mining investors are now beginning to fill this investment gap. Most commonly, these investors are trading and manufacturing organisations that need to meet the forecast production shortfall and are willing to take direct investments in mining companies to secure their future supply. They are willing to make significant, strategic investments that can form the cornerstone to funding new projects. The specialist knowledge players in other industries will introduce fresh thinking and innovation to the mining sector. Over the next three years, trading and manufacturing organisations will be the investors that have the most significant impact on the sector.



An aerial photograph of a mining site. In the upper left, there is a large pile of grey and white rocks. Below it, a yellow excavator is positioned on a dirt and rock surface. The background shows a vast, open mining area with scattered rocks and dirt.

'ACCESS DENIED' BECOMES THE NORM

PREDICTION 5

REGULATORY

MORE LICENCES WILL BE LOST DUE TO REGULATORY AND COMMUNITY INTERVENTION BY 2020.

In recent years, there have been several high-profile examples of licence refusals or cancellations for failures to meet regulatory requirements and community concerns. Examples include the recent government mining bans in the Philippines and the long-stalled permitting process for the Rosia Montana gold project in Romania due to concerted community opposition.

Resource nationalism is not a new phenomenon, and over the last 20 years, it has led to many countries introducing new mining taxes and royalties. The positive outlook for many commodity prices and overall mining sector profitability in the next three years could spur increased government attention on securing a share of mining profits. It could also lead to scrutiny from other new directions.

Because of the growing demand for tax transparency, governments of countries with significant mineral resources will be equipped to more effectively claim what they consider to be a fair share of mining projects' profits. At the same time, continuing advances in social media and technology will enable local communities and interest groups to be more effective and forceful in communicating their concerns and requirements for new mining projects.

Over the next three years, the mining sector will need to address these stakeholders' increased scrutiny collaboratively and strategically. Failure to do so will be costly, putting many mining licences at risk.

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BDO'S ENERGY 2020 VISION: THE NEAR FUTURE OF MINING IN THE US



INNOVATION BREEDS NEW SPECIES

PREDICTION 1

MINERAL X

DRIVEN BY INNOVATION IN THE SECTOR, A CURRENTLY UNKNOWN MINERAL WILL BECOME AN INTEGRAL PART OF THE US'S ENERGY MIX BY 2020.

The US mining industry spans a diverse set of familiar minerals, with coal, iron ore, copper, zinc, and limestone topping the list. By 2020, we predict there will be a new mineral among that list that will be a core contributor to the national energy mix.

A December [executive order](#) (EO) issued by President Trump could spur US mining companies to increase exploration for, and excavation of, a new commodity. The EO aims to reduce the nation's reliance on imports of critical minerals—a goal which "mineral X" could be instrumental in achieving.

Innovation will be a focal point of mining through 2020. Beyond discovering new minerals, research and development initiatives will play an essential role in a new commodity's emergence. Unmined resources remain unexplored largely because a practical use has not yet been identified, so no demand exists yet.

Mining companies that prioritize exploration in new minerals will also need to engineer demand.

Minerals in isolation often don't immediately have a concrete use, but when they are combined with other entities, their value could be tremendous. There are very few practical applications of zinc, for instance, but when it is adhered to steel, zinc stops it from rusting. Today, zinc has grown to be among one of the most valuable minerals in the world. In August 2017, the price of zinc hit a [10-year high](#). Once a practical application is identified, many industries are likely to tap into the new mineral.

Leading into 2020, innovative mining executives will adopt the mindset: Drill it, and they will come.



MINING DOES THE ROBOT

PREDICTION 2

AUTONOMOUS TECHNOLOGY

MOST MINING COMPANIES WILL GROW TO SPEND 10 PERCENT OF REVENUE ON INFORMATION TECHNOLOGY (IT) BY 2020, COMPARED TO JUST 1 PERCENT IN 2015. AS A RESULT, MANY US MINING ENTITIES WILL CONTINUE TO EXPAND EFFORTS TO INTEGRATE AUTONOMOUS TECHNOLOGY BY 2020.

Driverless technology, [deep sea excavations](#), and [mining expeditions on the moon](#) were once just the ideas of sci-fi movies. Today, they're near reality. Companies that fail to boost their investment in technology will be eclipsed by those that do.

As subdued commodity prices are expected to stay the norm, the value of harnessing technology is clear. Internet-connected devices allow mining companies to streamline operations, reduce expenditures, and keep prices competitive. Take [Rio Tinto](#) for example. It recently opened a processing center in Brisbane, Australia, to monitor and analyze processing data in real time from seven of its operations in the US, Mongolia, and at home. It will use the data it collects to optimize its mineral processing at those sites.

Driverless technology, meanwhile, increases mining output by 15 to 20 percent, and, at the same time, decreases fuel and maintenance costs by 10 to 15 percent and 8 percent, respectively, according to the [International Institute for Sustainable Development](#). But self-driving trucks are just the

beginning. US mining companies that digitize all their drilling—turning to automated drillers and Internet-connected sensors—will realize far more savings than those that don't. In fact, globally, we predict mining companies' per ton digging costs to decrease by more than 30 percent because of automation. As mining operations become increasingly digitized, the career path of a traditional miner will shift as demand increases for digital skill sets. Traditional operational positions—drilling, blasting, and driving—will be downsized and replaced by demand for remote operators and maintenance personnel.

Increased investment in technology—to the tune of 10 percent of revenue spent on IT—will make autonomous mineral excavation the norm for US mining companies. This will allow them to realize savings in reduced labor costs, maximized output, fewer safety incidents, and an increased ability to make data-driven decisions. Those that up their investment in technology will hold onto their customers over those that don't, as commodity pressures remain.





INCREASED FUNDING FUELS A NEW (CLEANER) BREED OF US COAL

PREDICTION 3

INFRASTRUCTURE FUNDING BOON

MORE THAN 10 PERCENT OF US NATIONAL INFRASTRUCTURE PROJECTS FUNDED THROUGH 2020 WILL BE PROJECTS IN THE MINING SECTOR.

The mining industry is on the brink of an infrastructure boom. Likely to jumpstart the increased exploration, President Trump signed an [executive order](#) in 2017 expediting environmental reviews and approvals for high-priority infrastructure projects.

Removing some regulatory roadblocks could pave the way for US exploration in minerals and entities outside the nation's core energy mix, such as lithium. The US currently has just one active lithium mine, the [Silver Peak mine in Nevada](#). As more states follow California's lead leveraging lithium batteries to store renewable energy and supplement their electrical grid, the US mining industry could be incentivized to meet increased demand.

In addition to investment in emerging minerals, we expect coal mining will continue to drive a large portion of mining activity in the US through 2020. While coal production has decreased in recent years—declining [nearly 20 percent](#) in 2016—the sector will continue to refine the mineral for reduced environmental

impact to remain competitive with renewables. Cleaner coal's market share has already started to grow. Refined coal—processed to remove pollutants—comprised nearly one-fifth of last year's US power sector's coal consumption through September 2017, compared to 17 percent in 2016, according to a September 2017 US Energy Information Administration [\(EIA\) report](#).

Expanded investment in US infrastructure—regardless of the types of projects initiated—is

welcome news to miners. Minerals like iron ore, which is used to make steel, form the backbone of new buildings, roads, and railways. The construction industry also drives [nearly 50 percent](#) of the nation's copper demand. Contractors put copper to work in roofing, electric wiring, and plumbing, to name a few uses. As the nation breaks ground on infrastructure improvements, the mining industry could see a spike in demand.



CONTINUED DISRUPTIONS (NOT THE GOOD KIND)

PREDICTION 4

DISTRIBUTED DENIAL OF SERVICE

BY 2020, MORE THAN 1 IN 5 MINING COMPANIES IN THE US WILL BE THE VICTIMS OF A DISTRIBUTED DENIAL OF SERVICE (DDOS) ATTACK.

The same technologies empowering US mining companies to streamline operations, reduce expenditures, and keep prices competitive open them up to new cyberattack vectors. Mining companies that fail to update cybersecurity controls in line with the pace of their technological innovation risk putting their entire operation in jeopardy.

"In today's competitive global market for commodities and manufactured goods, the reliance on natural resources for economic development and fluctuating geopolitical climates have all contributed to making industries targets for cyber espionage campaigns, and in extreme cases disruptive and destructive cyberattacks," Trend Micro wrote in a [report](#) on cyber threats to the mining industry. "Cyber campaigns are...used for conducting carefully planned strategic or retaliatory cyberattacks against a nation's critical infrastructure."

Any disruption to the US power grid—the electricity source of mining companies—has the potential to impact autonomous and semi-autonomous grinding mills, ball mill drives, conveyor belts, crushers, shovels, bucket chain excavators, and other major mining equipment. Already in [October 2015](#), a data-destroying parasite known as KillDisk entered the systems of numerous notable Ukrainian companies through a malware program known as BlackEnergy. Just two months later, that same parasite took down a power grid in western Ukraine after lying dormant in the systems of three major power companies for months.

In [2017](#), Europe and North America's energy sectors were highly targeted by a group known as Dragonfly in a wave of attacks meant to severely disrupt infected operations. We see US mining companies as the ones with the target on their backs in the next few years. By 2020, 1 in 5 will be the victims of a large-scale DDoS attack—either through a direct attack or indirectly through attacks on the power grid.



BRINGING DEEP-SEA MINING TO LIFE

PREDICTION 5

DEEP-SEA MINING

DEEP-SEA MINING EXPEDITIONS WILL BECOME COMMON BY 2020 IN THE US INDUSTRY, AND THERE WILL BE A US LAW ESTABLISHED TO REGULATE THE PRACTICE AND ITS ENVIRONMENTAL IMPACTS.

Following President Trump's 2017 [executive order](#) to streamline US mining projects in minerals—from cobalt and lithium to rare earths used in magnets for turbines and electric car motors—momentum will be strong for US expansion into deep-sea mining.

According to scientists, engineers, and industrialists, mining the deep ocean floor for metals is inevitable and vital. "The special metals found in rich deposits there are critical for smart electronics and crucial green technologies, such as solar power and electric cars," *The Guardian* [reported](#). "But as the world's population rises, demand is now outstripping the production from mines on land for some important elements."

Adding more urgency to the US's shift toward deep-sea mining is the fact that [China is currently the single source](#) of rare earth elements that can also be found in the deep ocean.

As of 2017, the UN's International Seabed Authority, the regulator of the seafloor that lies outside of nation-state jurisdictions, has already

granted more than 24 contracts for deep-sea mining. And one of the world's first and largest deep-sea mining expeditions is set [for 2019](#). Canada's Nautilus Minerals Inc. is set to lower three remote-controlled mining robots to the floor of the Bismarck Sea off the coast of Papua New Guinea in search of copper and gold reserves. This operation will unleash a deep-sea mining tsunami as companies around the world rush to compete.

But while proponents of the practice say the extraordinary richness of the deep-sea ores equate to lower environmental impacts than land mining, opponents argue that ecosystems could be destroyed and should be protected. By 2020, the Organisation for Economic Co-operation and Development (OECD) countries will agree to an international treaty to ensure the responsible exploitation of deep-sea resources. And the US will follow suit.

By 2020, a presidential election year, environmental protections could shift back to pre-2017 norms, depending on who is ultimately

elected. Environmentalists, pushing for US regulators to develop their own domestic laws around deep-sea mining—ones stronger than those of the OECD—will succeed. Mining companies will turn to new types of technologies to ensure low environmental impact in compliance with the regulation, and a new subsector of comply-tech will take shape in the industry.

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