

An aerial photograph of a large-scale mining operation. The scene is dominated by dark, textured earth and rock. In the center, a complex network of conveyor belts and heavy machinery, including large excavators and trucks, is visible. The machinery is primarily orange and yellow. The overall atmosphere is industrial and powerful. The lighting is dramatic, with strong shadows and highlights.

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

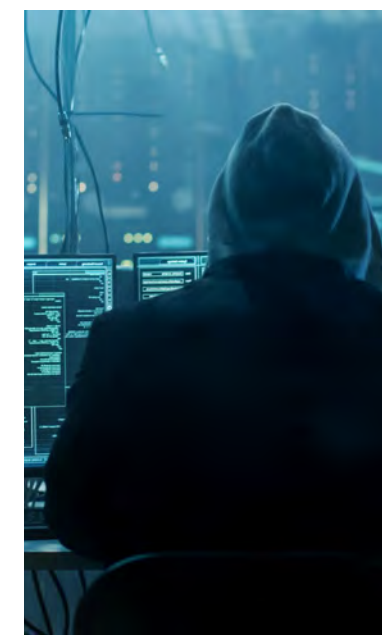
BY 2020, ACTIVIST HACKERS WILL LAUNCH AT LEAST FIVE CYBERATTACKS ON MINES AROUND THE WORLD IN PERMANENT DENIAL OF SERVICE (PDoS) ATTACKS AIMED AT ELIMINATING THE ENVIRONMENTAL AND SOCIAL THREATS THEY POSE. THEY'LL USE WORKERS' CONNECTED DEVICES TO LAUNCH THE ATTACKS.

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

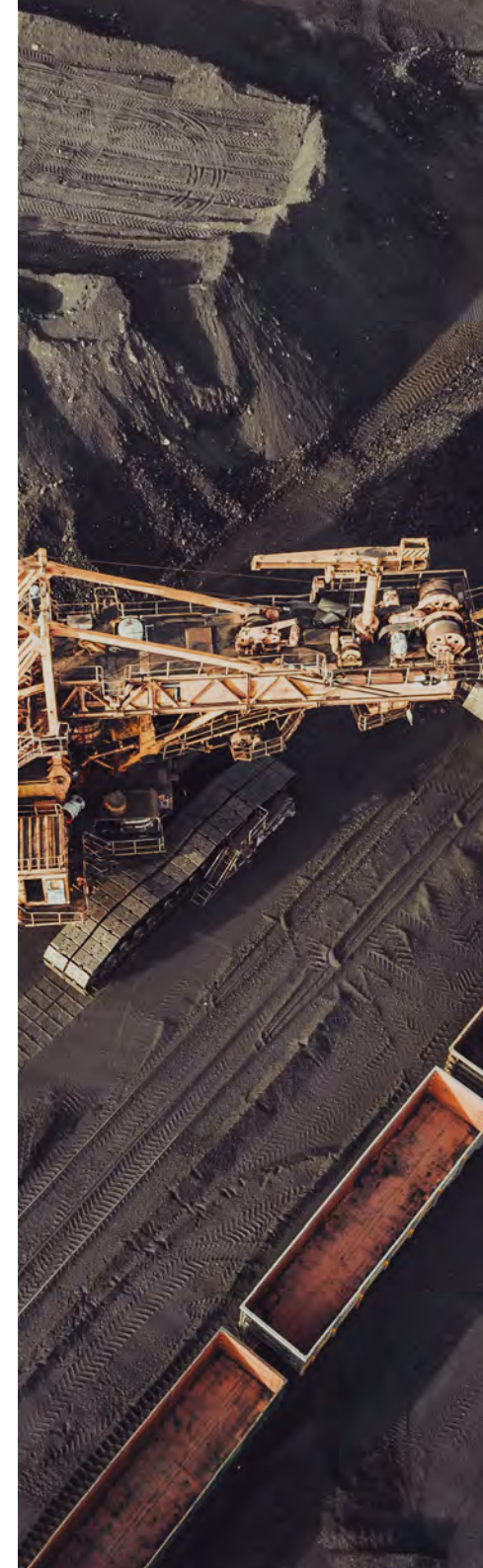
BY 2020, RENEWABLES WILL ACCOUNT FOR ONE-QUARTER OF THE WORLD'S ELECTRICITY GENERATION AS DEPENDENCE ON COAL WANES.

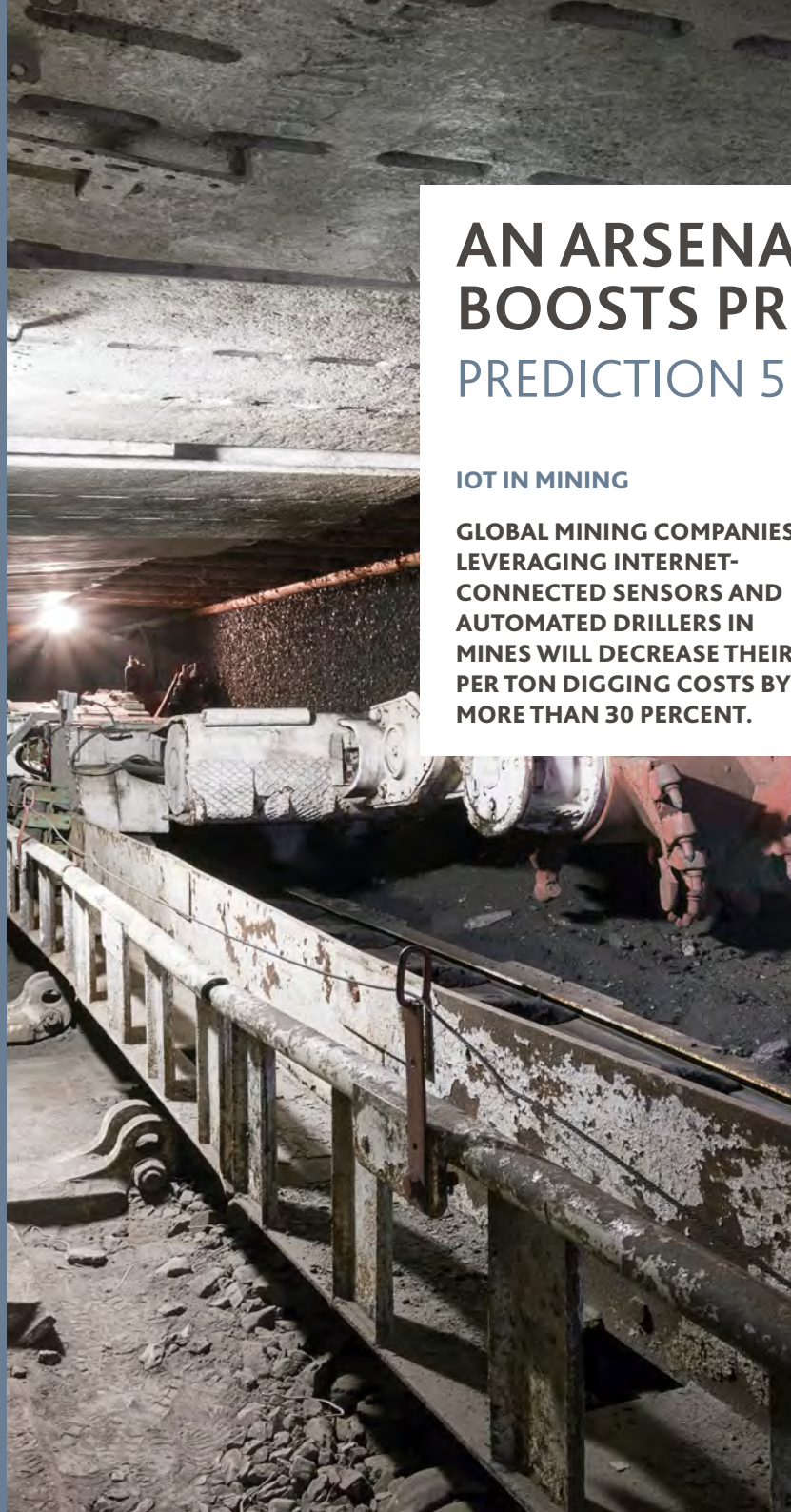
Decreased coal consumption in China—the world's largest coal consumer—is slowing global demand for the commodity. According to the International Energy Agency, global coal consumption decreased about 2 percent last year. In confluence with the rapid growth of renewables, the world's energy mix is set 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

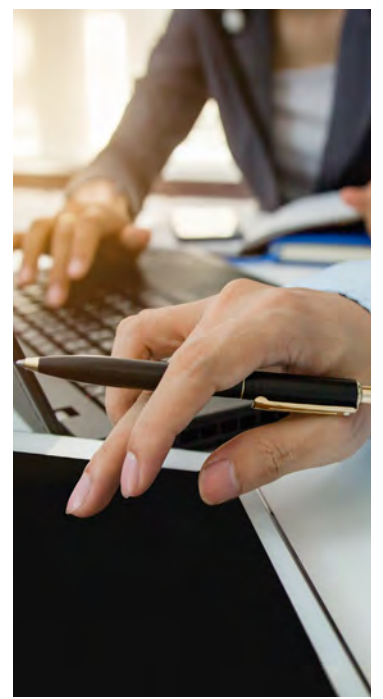
IOT IN MINING

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 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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