



Powering the future of mining
From energy technology to core design

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Introduction



Declining ore reserves have been pushing mining companies to seek opportunities in ever-more remote locations and driving innovation across the industry. As mining leaders face this mix of challenge and opportunity, energy remains integral to the success and profitability of projects. Among other factors, energy-supply constraints, exposure to energy price volatility, and new environmental regulatory frameworks and licensing requirements are increasing the pressure to generate and use energy in a cleaner and more efficient way. As a result, the leaders developing the mines of tomorrow must create energy strategies and learn to integrate energy solutions into their operations.

The drive toward socially conscious profit is no longer limited to environmental activists. Much of society as well as investors are demanding greater transparency concerning the true social, economic, and environmental impact of sectors such as mining. There is a need to achieve carbon neutrality by making energy a core focus of overall design and operational planning and execution, throughout the life of the mine and beyond.

In that context, it's critical to understand the dynamics emerging around energy. The increasing pressure on the industry to generate and use energy in cleaner and more efficient ways stems from a confluence of factors, including:

- **Energy security**

With companies increasingly exploring remote locations, developing the skills and the capabilities for securing reliable off-grid energy sources and using energy more efficiently is becoming a key innovation driver for new mine developments.

- **Productivity decline**

Some mines have been facing a get-less-for-more situation, with one study showing average copper ore grades decreasing by roughly 20 percent from 2005 to 2017,¹ resulting in upping energy requirements per output.

- **Technological innovations**

Energy, mining, and information technologies have driven financially viable alternatives to fossil fuel, with the Levelized Cost Of Energy (LCOE)² for wind and solar dropping dramatically, by 69 percent and 88 percent respectively, from 2009 to 2018.³

- **Stakeholder pressure**

The trend toward responsible investing has seen individual investors and institutional asset managers alike integrating environmental, social, and governance (ESG) principles into their decision-making. Particular attention is being paid to how companies are addressing issues such as climate change, energy, and water management, all important aspects of mining operations. Governmental policy regarding carbon pricing, incentive programs, licensing requirements, and recognition of certain particulates as dangerous gases has increased the need for clean energy solutions.

- **Energy price volatility**

Fluctuation in energy prices has significant impact on profit margins, as energy costs can represent about 20-30 percent of total operational expenditures depending on the location and type of mining.

¹Ame Research, Feb 2018, "Declining copper ore grades"

²The net present value of the unit-cost of electricity over the lifetime of a generating asset

³Lazard, Nov 2018, "Levelized Cost of Energy and Levelized Cost of Storage"

Previous reports in this series highlighted the extent to which industry adoption of innovations like workplace designs, artificial intelligence, and wearable technologies has already advanced and improved operations, particularly in the areas of safety, productivity, and talent management. This report draws on the knowledge of experienced professionals from both Deloitte and NORCAT-affiliated companies, to better understand what leaders need to think about in terms of integrating energy solutions. The report reveals a need for disciplined and holistic approaches to navigating the myriad different technologies, each of which can be a game-changer unto itself but, taken together, represent the opportunity to reshape the way mines are designed and steer energy strategies toward broader transformational shifts.

“Mining companies nowadays have to satisfy investors, local communities, and governments by demonstrating that they are serious about dealing with energy transition and aiming for net-zero sustainability.”

- Tim Biggs

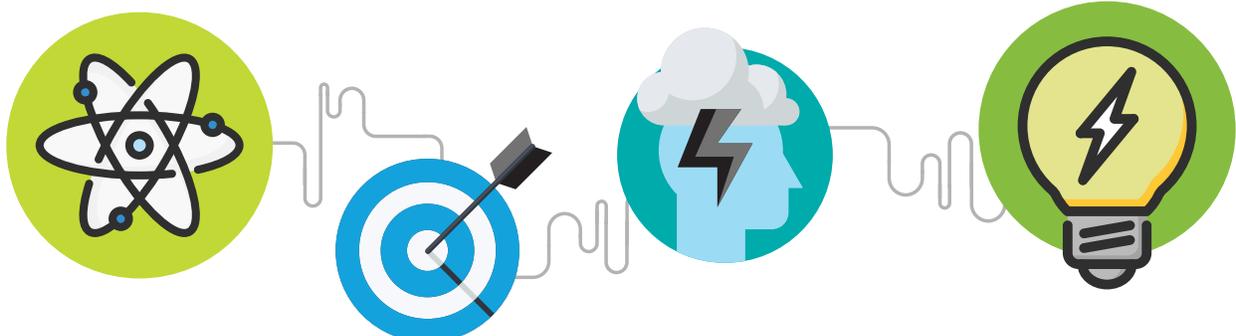
*Partner, Deloitte EMEA and UK
Sector Mining & Metals Leader*

The report also notes the importance of developing a thorough understanding of the key considerations involved in a modern energy strategy and its successful execution. Mine leaders must start by addressing key questions, such as:

- **What are the main challenges in implementing energy solutions in the mining industry?**
- **What are some of the approaches mining technology companies have used in addressing those challenges?**
- **What are the steps mining leaders should take to review and express their energy strategies?**

Using case studies from the industry will help them think about new and innovative solutions that best fit their current challenges. It will also inform the articulation of a strategy that positions energy as central to designing the mine of the future.

Arriving at a strategy, however, requires a disciplined approach. This report therefore also outlines a methodology Deloitte has developed to help mining leaders think about those challenges in a structured way: developing and articulating different strategies to assess energy waste, supporting the integration of energy technologies, and rethinking new mine design. In short, this framework provides leaders a more informed and strategic approach to large-scale transformation today that will afford the competitive advantages of tomorrow.



Several benefits

Mining companies that have started implementing emerging energy technologies are realizing a wide variety of benefits, including:



Cost savings

Off-grid, renewable energy can reduce operational expenditures and carbon emission costs to the point that its LCOE now competes with that of fossil fuels. On-grid, batteries help to synchronize energy supply and demand, and shift work away from higher-price peak hours.



Predictability

Paired with storage capabilities, renewables can also increase predictability of energy supply and prices, thereby strengthening the precision of financial models that mining companies use to manage their risk.



Revenue generation

By selling excess generation capacity or reselling stored energy during high-demand periods, even long after mine decommissioning, mining companies can generate revenues from energy assets.



Reputation, license, and social acceptability

Especially in remote locations, clean energy sources that outlast the life of the mine can help generate trust and show the will to include and cooperate with local communities.



Health, Safety and Environment (HS&E)

Electrification of mines, including the transition to electric vehicles, can help create a safer and cleaner environment for front-line workers, including higher air quality for those working underground.

Turning the light on



With the highlighted trends and factors showing no signs of fading, it is no surprise that emerging energy solutions will increasingly bring benefits to the mining industry.

As with almost any significant shift away from the status quo, however, there are challenges and barriers to the successful integration of new technologies that typically require complex and cross-functional transformations, including:

- **CAPEX-OPEX trade-offs** – usually the result of companies focusing on the up-front investments required rather than on the holistic benefits of energy solutions in the more strategic long run
- **Integration with existing infrastructure** – the practical and conceptual difficulties of introducing new technologies into an older infrastructure

- **Energy implication beyond the life of the mine** – companies not recognizing the potential of harnessing energy solutions that outlive the mine
- **Unlocking full benefits of innovation** – missing out entirely on the benefits of energy innovations due to the technical and cultural complexity of integrating multiple solutions (e.g., storage, generation, grid)

To shed light on how leaders can overcome these hurdles, Deloitte teamed up with NORCAT to conduct a series of interviews with technology companies in the NORCAT ecosystem as well as leaders from the mining industry to better understand some of the approaches already being used to address these challenges.

The CAPEX-OPEX trade-off

Because mines sometimes take decades to recoup their initial investments, mining companies face the challenge of balancing net benefit from the short to long term, sometimes affecting the implementation of capital-intensive technologies intended to reduce large operational expenditures. These innovations can also drive increasingly important but less easily quantifiable benefits, such as energy predictability, regulatory compliance, and social acceptability. While capital intensity accounts for the lion's share in determining the economic feasibility of a development project, companies are finding ways to address this challenge.

For example, Montreal-based **TUGLIQ** – a specialized independent power producer delivering diesel-alternative solutions using local and proximity resources – uses flexible contract options, project risk sharing and predictable energy costs for the mines over the duration of the asset.

“Once renewables are set up, wind and solar have the advantage as they are free and predictable in cost downstream.”

- TUGLIQ

Or consider **Hydrostor**, a developer of utility-scale energy storage facilities using its proprietary Advanced Compressed Air

Energy Storage (A-CAES) technology. A-CAES technology can be deployed to repurpose de-commissioned underground mines for the provision of long-duration energy storage which, paired with low-cost green power, provides a baseload of dispatchable renewable product directly to the mine. To address this challenge, Hydrostor offers fully financed solutions that Hydrostor owns and contracts out or can deliver as a turnkey asset to help mining companies adapt the risk profile of their mine operations and take advantage of high-value applications behind the meter.

“Businesses should start thinking about energy as a key value driver from an economic cash-flow perspective instead of treating it as discrete and separate CAPEX and OPEX decisions.”

- Adriaan Davidse

*Consulting Director
Deloitte Canada*

Integration with existing infrastructure

Identifying and then implementing technologies that allow for the integration of older models and new upgrades can be exceedingly tricky. The good news is that more and more technology companies are addressing the issue with key design challenges and features in mind.

MacLean Engineering is a mining vehicle manufacturer of specialty underground mining vehicles – including battery electric vehicles. They have designed their vehicle line to charge directly from the existing electrical infrastructure at mines – no charge stations required - while remaining adaptable to further innovation. This onboard charging feature in particular is one of the ways MacLean ensures its technologies can be deployed today in a wide variety of existing and new mines.

U-Battery a consortium of companies that is developing a Small Modular Reactor (SMR), ensures the design of their SMR complements and enhances the varying energy generation types typically found in different mining contexts. Its design incorporates inherent safety features eliminating the need for complex, and expensive cooling and safety systems. Its fuel-replacement cycle of five years allows for low maintenance, and it's capable of load-following to swiftly adapt to a wide range of mining electricity and heat demands. U-Battery also considers their product as complementary to other energy generation means, thereby creating a reliable, and dispatchable energy source that enables the use of intermittent renewable sources and/or displacing all or a portion of diesel combustion.

“Mine infrastructure will undoubtedly evolve and you need to be able to adjust to that as the industry changes.”

- MacLean Engineering

Energy implication beyond the life of mine

It can be more difficult for the types of mines with shorter lifespans to envision the benefit of technologies that extend past the life of a mine. This is central to why the mining innovation network is seeking solutions such as developing modular renewables technologies that are re-deployable to other sites, better quantifying the non-financial benefits of energy solutions, and finding ways to derive value from the energy assets in surrounding operations and local communities.

Other ways **TUGLIQ** copes with renewable energy assets and infrastructure extending beyond the life of mines include “buy out” provisions, whereby the mine indemnifies the developer by awarding a residual buy-out payment accounted under de-mobilization expenditures already capitalized at the time of the mine’s permitting.

For their part, **Hydrostor’s** technology solution has a long asset life (50-plus years), turning decommissioned liabilities in the form of underground mining infrastructure into a valuable energy storage asset. These

assets can serve as long-term energy storage, with the potential to generate additional revenues for mining companies by serving surrounding mine operations and/or local grid needs through participation in energy markets to the benefit of local communities.

“Progressive jurisdictions are increasingly asking for a plan to diversify away from diesel over the life of the mine as part of the vetting process of licence applications. Getting this plan from the outset gives an advantage in speed-tracking licensing.”

– TUGLIQ

Unlocking full benefits

Energy solutions tend to be cross-functional and touch many aspects of the business, pushing mining companies to embark on

massive transformations involving broad cultural shifts as well as investigating the complex interrelationship of complementary technologies. Implementing and operating energy solutions typically requires other digital or mining innovations as well as different types of capabilities and infrastructure (e.g., analytics, sensors, batteries, intelligent digital grid).

U-Battery itself represents an example of how different players across multiple sectors can join forces to tackle complex technologies: this network of companies was created to maximize pools of talent and complementary knowledge, thereby accelerating innovation. Its connection to academia and industry expertise broadens its innovation network, facilitating a deeper understanding of industry needs and the technologies that can advance the commercialization of SMRs. These connections allowed U-Battery to expand beyond energy generation and consider the benefits to mining operations and local communities – such as utilization of by-product heat for greenhouse crops, the desalination of water, and the production of hydrogen.



Numerous use cases exist for handling challenges faced in the drive to adopt new energy solutions. With mining companies continuing to realize that both financial and non-financial benefits come from a wide range of energy solutions, advances in technologies and approaches will only continue to accelerate. In some cases, adopters of emerging energy solutions will enjoy benefits well beyond the life of the mine, such as social licence and revenue generation.

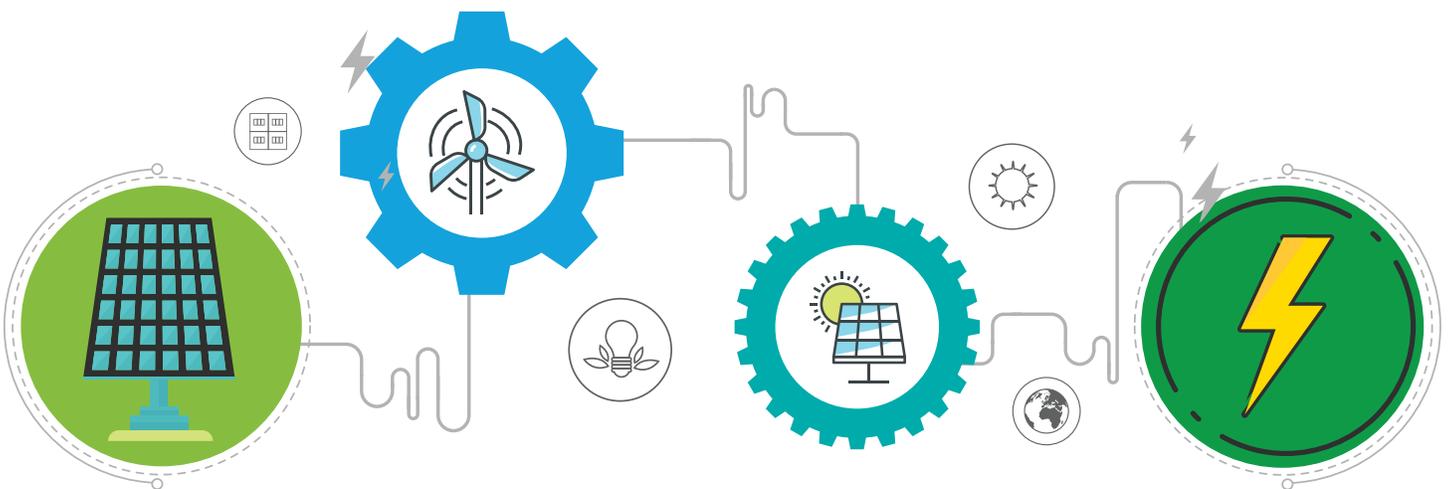
“By making optimizing energy flows a key consideration of mine design and planning, rather than a consequence of it, significant improvements can be realized.”

– Adriaan Davidse
 Director, Consulting
 Deloitte Canada

This rapidly evolving context, however, means mining leaders need more than ever to be strategic in their adoption planning to be competitive in the longer run. In short, it means they need to consider:

- Reviewing and expressing a holistic energy strategy on multiple time horizons, by assessing existing energy capacity and technology starts through the right questions
- Developing ways to enhance decision-making processes by considering all the benefits of energy solutions throughout during and beyond the life of the mine, including where new technology fits into existing infrastructure and factoring in the impact on and value to the community
- Considering all stakeholders involved in energy solutions and participating in the mining innovation network including the potential for other industry players to engage in a constructive discussion on how to tackle specific challenges and adopt certain technologies in an integrated fashion

Some mining companies are already acquiring the skills and capabilities of integrating new energy technologies and assets into their operations, which will make them the ones best positioned for developing the mines of the future. For the rest, what can their leaders do to accelerate the energy strategy process in their own organizational and operational contexts, while also enhancing their chances of success?



Articulating an energy strategy



As with any successful technology integration, it's crucial that mines are developed with the right tools, culture, and processes. Competitive advantage in mining will hinge on the ability to secure energy in remote locations and develop low-carbon products that can sell for a premium and appeal to a broader range of customers, as more and more institutions consider carbon footprints in their bid-awarding processes.

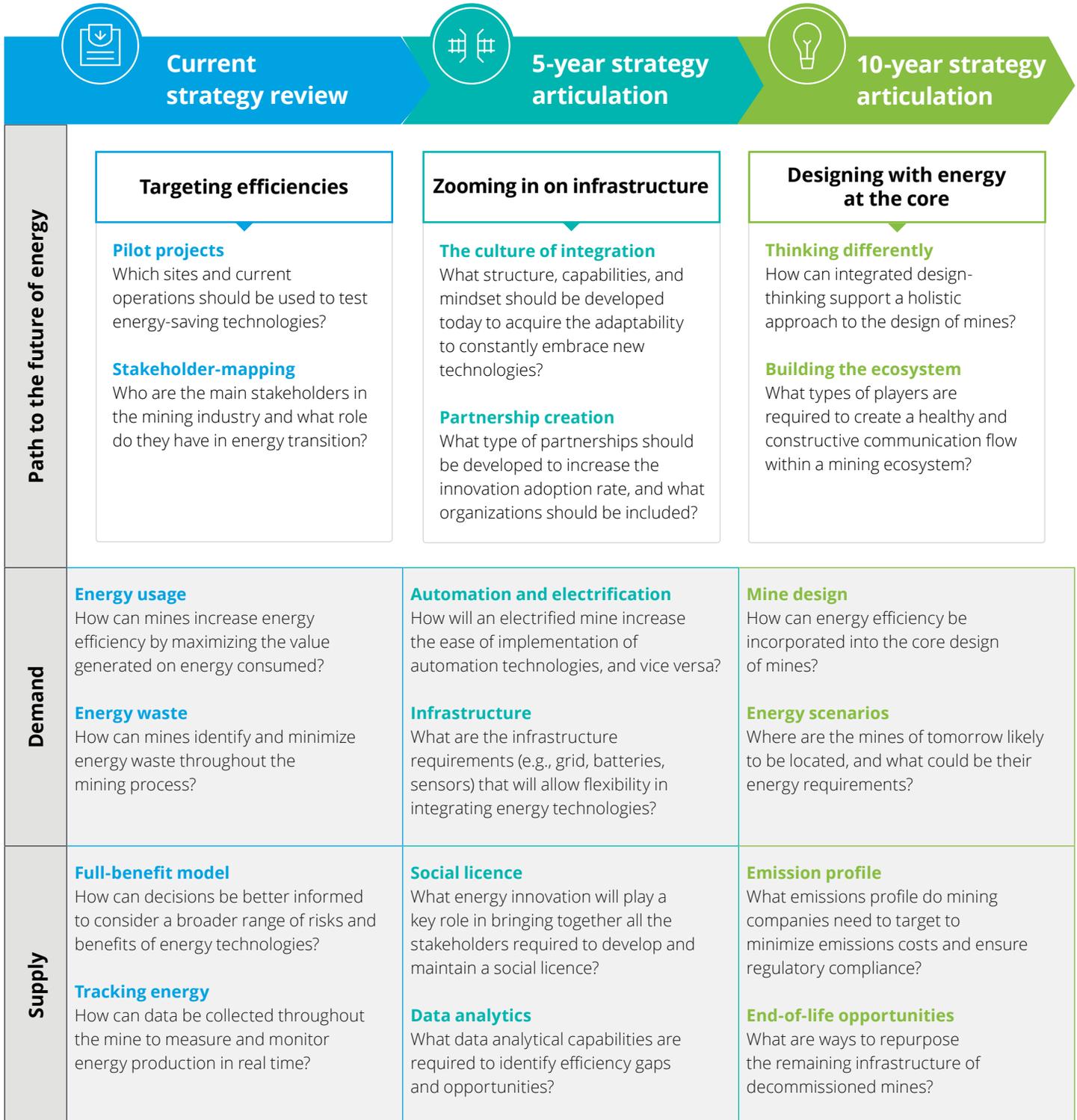
And while acquiring the practical skills and capabilities of integrating such processes and assets into their operations remains mission-critical, strategies must embrace a holistic rethink of energy production and consumption. To help leaders think through these challenges and opportunities in a structured way,

Deloitte has developed a framework that supports mining leaders in articulating the multiple horizons that are required to move the organization in the right direction.

Mining companies that thrive in the future will have thought about energy strategy through three lenses, keying in on energy

waste reduction and efficiencies in the short term, the implementation of technology innovation in the medium term, and overall mine design from an energy perspective in the longer term. When viewed over these different time horizons, key questions foundational to the mine of the future come firmly into focus.

A question of strategy





While there's no easy way to overcome the challenges and barriers to designing the low-carbon mine that takes electrification and automation at its core, the adage about predicting the future by inventing it has perhaps never been more apt. Indeed, this is just the beginning for energy technologies. And since they're sure to be top of mind for mining leaders over the coming years, the need for deeply informed strategy has never been stronger.

"Mining of the future is significantly different from mining of the past. The automated mines using a workforce with entirely different skillsets will shift towards data and analytics and require mining leaders to develop an ecosystem to drill more intelligently and mine more accurately."

- John O'Brien

Partner, Deloitte Australia

The future of energy in mining

Solving for context

The trend toward electrification, digitization, and decarbonization means leaders need to understand the benefits to the business – and the potential implementation challenges—to plan and adjust to the new energy future. With the cost reductions, predictability of energy costs, as well as social licence and acceptability factors already well in play in the industry, more examples and success stories of large-scale energy solution implementations can be expected as leaders expand their understanding of the role of energy in the mine of the future.

At the same time, the absence of one-size-fits-all solutions increases the burden of exploration and assessment on mining leaders, leading them to have to test all possible technology combinations. Understanding these interrelationships can be difficult, time-consuming, and costly, especially when each mine has a unique context. It is imperative that technology and mining companies find the right balance of flexibility to create a tailored solution for the specific context of an operation.



Contact information

To discover some of the best approaches of energy solution implementation or to discuss which steps you should undertake as part of your energy strategy, contact us today:

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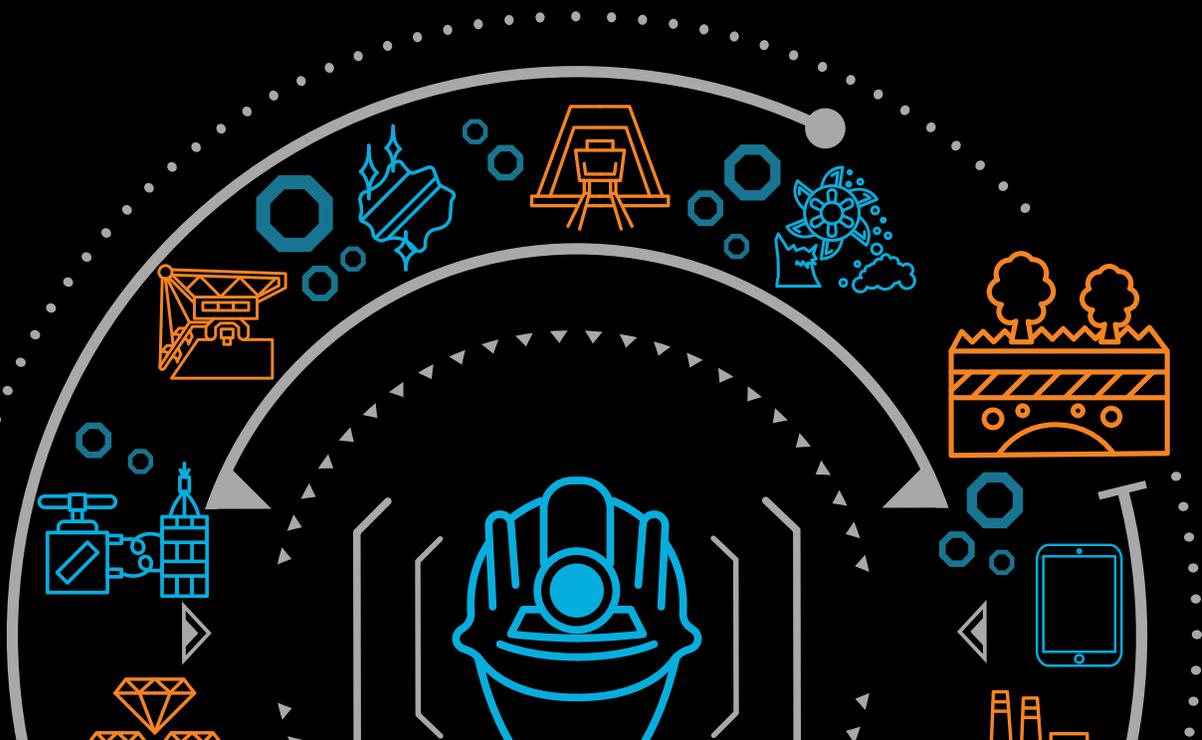
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About Deloitte/NORCAT partnership

Overview of the Deloitte NORCAT partnership

Deloitte, one of Canada's leading professional services firms, provides audit, tax, consulting, and financial advisory services. Deloitte LLP, an Ontario limited liability partnership, is the Canadian member firm of Deloitte Touche Tohmatsu Limited. Deloitte is one of the world's largest professional services firm in mining with a footprint covering all the world's major mining geographies.

NORCAT is the only non-profit regional innovation centre in the world that has an operating mine designed to enable startups, small and medium enterprises, and international companies to develop, test, and showcase new and innovative technologies in an operating mine environment. This unique facility anchors one of the world's leading advanced manufacturing and mining technology clusters and represents a "one-stop-shop" to see future technologies and innovations that are poised to transform the global mining industry.

NORCAT's Underground Centre has been working with mining companies to understand the urgent need for training—for both

new and existing workers—on the efficient, productive, and safe use of new technologies.

To accomplish this, NORCAT has worked with clients, government, academic institutions, and partners over the past 20 years to develop an array of integrated training and development programs to serve multiple sectors both in Canada and around the world. As part of their strategic partnership, Deloitte and NORCAT are taking steps to help the global mining industry better understand emerging mining technology and innovation trends. Their goal is to combine on the ground insight gained from companies that have installed emerging technologies at the NORCAT Underground Centre with the market knowledge of the Deloitte global mining team.

Special thanks

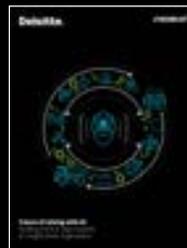
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Publication series

Other articles Deloitte has developed in collaboration with NORCAT focus on:

- How the mining industry is adopting a *human-centred design* approach to mining innovation
- How the *future of work* in mining will affect both front-line employees and leadership
- How organizations can take the first steps toward a *future of mining with AI*
- How mining companies can harness the hype of the *future of mining with wearables* to improve safety

All reports can be found on the webpage **Deloitte and NORCAT: Collaborating to explore the future of mining** at www.deloitte.ca.



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www.deloitte.ca/mining

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