

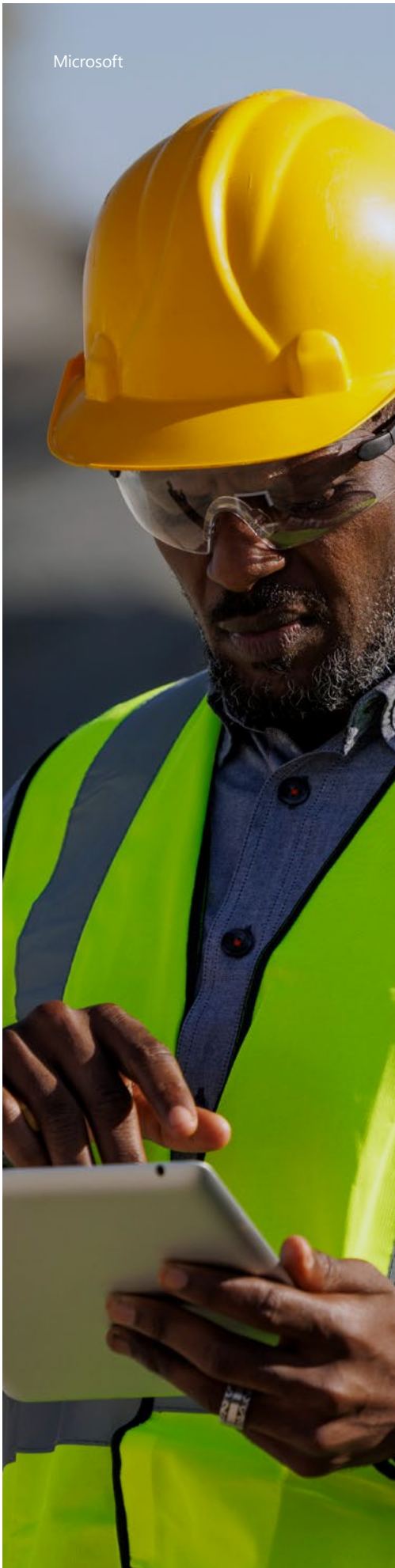


# Building the mine of the future in the industrial metaverse

How the virtual frontier is driving growth, innovation, and sustainability

# Contents

<a href="#">Page 3</a>	Overview >
<a href="#">Page 4</a>	Building the mine of the future >
<a href="#">Page 6</a>	The technology powering the industrial metaverse >
<a href="#">Page 8</a>	Envisioning the mine of the future >
<a href="#">Page 11</a>	The current state of the industrial metaverse >
<a href="#">Page 19</a>	Leading a people-first transformation >
<a href="#">Page 22</a>	Partnering wisely for the journey ahead >
<a href="#">Page 25</a>	Contributors >
<a href="#">Page 26</a>	Sources >



# Overview

Discover how you can build the mine of the future in the industrial metaverse with insights and guidance from global mining and technology experts.

- Reduce engineering, manufacturing, service, and supply chain silos with a 360-degree view of what's happening across the value chain.
- Unify disconnected applications and data into a secure, integrated technology estate to unlock insights that improve products and operations.
- Empower employees with the technology and skills they need to achieve more, without compromising safety.
- Use AI to move from reactive to proactive, taking advantage of copilots alongside immersive devices to operate more efficiently as you build a new energy future.



# Building the mine of the future

Throughout history, miners have extracted the value hidden beneath our feet and used it to change the world. From tin in the ancient mines of Cornwall to gold in 1800s California to critical resources fueling today's electric vehicles, miners have unearthed the minerals and metals that have powered human progress, innovation, and economic development.

Today, the demand for raw materials to develop batteries, solar panels, wind turbines, and other clean energy technologies has soared. And while mining leaders are racing to meet increasing demand, they are also balancing this need with the energy trilemma—seeking to provide safe, sustainable, and equitable energy for all.



- Between 2017 and 2022, energy sector demand was the primary driver behind a tripling in overall demand for lithium, a 70% jump in demand for cobalt, and a 40% rise in demand for nickel.<sup>1</sup>
- The mining industry must quadruple mineral production to meet clean energy technology goals outlined in the Paris Agreement technologies by 2040.<sup>2</sup>
- Reaching net zero globally by 2050 will require a sixfold increase in mineral inputs.<sup>2</sup>

As they seek to address these challenges, today's market leaders are recognizing that:

- Time- and capital-intensive decisions made today will shape their transition for the next decade and beyond.
- Slow or cautious resource development could result in a massive gap in delivering the critical resources, minerals, and metals when they are needed.
- Transforming their businesses with AI will be critical to using the raw material of data to innovate and deliver at speed and at scale.

Enter the industrial metaverse, which is the convergence of Internet of Things (IoT), digital twins, simulation, and mixed reality. It's transforming how we interact with industrial products, processes, and places, unlocking innovation and unleashing greater value.



# The technology powering the industrial metaverse

## Generative AI

Generative AI plays a crucial role in shaping the industrial metaverse, which integrates technologies like IoT, AI, digital twins, and mixed reality. It enhances efficiency, innovation, and sustainability within the industrial metaverse, making it a critical component for organizations in the energy and resources industry.

## IoT

IoT technology enables the fusion of physical and virtual realities within the industrial metaverse, reshaping the landscape of global industry and promoting efficiency, sustainability, and collaboration. It allows organizations to collect real-time data about equipment performance and health, environmental conditions, and other critical measurements.

## Cloud platforms

Cloud platforms are foundational to the industrial metaverse, helping ensure seamless data flow, advanced analytics, collaboration, and immersive experiences. These platforms help an organization to gain better visibility and improve decision making by connecting its vast data streams and facilitating both internal and external collaboration.

## Edge computing

Edge computing plays an essential role in synchronizing the physical world with the digital world. This technology provides efficient data processing, low latency, and improved bandwidth usage, making it a vital component for creating a connection between the physical world and the virtual realm of the industrial metaverse.



### **Digital twins**

Digital twins allow for effortless integration between the physical and digital realms. They serve as interconnected entities within the enterprise metaverse, replicating everything from physical assets to core business processes. Their interoperability with emerging technologies drives the next evolution of the connected, intelligent industrial metaverse.

### **Robotics & automation**

Robotics and automation, along with these other technologies, boost productivity, safety, and efficiency across various industrial domains.

### **Machine learning & simulation**

Machine learning and simulation are crucial components in shaping the industrial metaverse. Machine learning enables data-driven intelligence, while simulation allows for experimentation and optimization.

### **Mixed reality**

Mixed reality combines technologies like IoT, AI, and digital twins with augmented and virtual realities to provide immersive, 3D experiences of modeled data. It can increase productivity, safety, and efficiency in industrial settings by blending the physical and digital realms, visually empowering workers with contextual information and interactive experiences.

An aerial photograph of a massive open-pit mine. The mine is characterized by numerous horizontal terraced levels, creating a stepped appearance. The rock faces are dark and rugged, while the flat surfaces of the terraces and the winding roads are a lighter, sandy brown color. The perspective is from a high angle, looking down into the mine's depths. The overall scene is one of large-scale industrial excavation.

# Envisioning the mine of the future





Similar to the minerals and metals that your company extracts, veins of data run through your business. Beneath the surface, vast stores of information are waiting to be unearthed, refined, and processed into valuable insights. When data is connected across all your digital solutions, you gain a more complete understanding to make better decisions, smarter predictions, and faster reactions every step of the way. That's the potential of the industrial metaverse.

You may already be using some of the technologies that constitute the industrial metaverse. Machine learning has been in use for years, and sensors, IoT, and analytics are already powering remote operations centers that are changing the way mines operate.

But for many companies, these implementations have led to hundreds of siloed systems that make individual tasks more efficient while leaving larger opportunities unseen and untapped. To embrace the industrial metaverse is to make one important change: creating a connection between people, processes, and data.

By connecting data across your business and technology, you can turn what you already have into an accelerator for growth.

But what does that look like? Sue Keay, Founder and Chair of the Robotics Australia Group, describes what the mine of the future can look like with the help of the industrial metaverse:

“The industrial metaverse can make zero-entry mines possible. With mixed reality, there may come a time when you don’t need to have people physically on a mine site. People wouldn’t have to move far from home or risk dangerous conditions to do their job. Companies would be able to remotely operate machinery and predict when it’s likely to experience failures. They could reduce energy usage by charging equipment on an optimized schedule and make sure the entire fleet is working together. Eventually, this technology can help us move toward designing machines that are maintained by machines. This is crucial because, as resources get scarcer, we’re going to have to dig in deeper, more dangerous environments for humans.

In the future, we’ll also be mining for ore in smaller areas. Being able to run simulations and use smaller autonomous vehicles can fundamentally change the way that mines are designed and operated. We can intentionally craft mines that have a shorter lifespan and less impact on the environment. The industrial metaverse will help us change the paradigm that mines are long-lived and capital-intensive assets.”

The latest technological advances get mining closer to a zero-entry future, but the industrial metaverse is already helping industry leaders solve the problems of today.



# The current state of the industrial metaverse

Although mining sits at the center of energy transition goals, the industry must also weather global uncertainty and social challenges that impact short-term planning. Business transformation is driven as much by practicality as it is by vision. In a time of disruption, it can be hard to decide which threats to respond to and which opportunities to pursue.

Overcoming these interrelated challenges is dependent on having complete information about the past and present, then using it to fundamentally shift operations for the future. Companies are already using the digital metaverse to optimize from mine to market.

# Next-generation remote operations

In recent years, industry leaders have improved their remote operations with the industrial metaverse, ushering in an era of integrated remote operation centers (IROCs) that incorporate data streams across multiple functions, multiple assets, and even the entire value chain. With IROCs, these companies are better able to monitor, control, automate, and make impactful decisions.

Remote operation centers (ROCs) have been in use for well over a decade, adopted by all of the mining industry's major players to reduce costs while improving productivity and safety. Remote monitoring and control, along with data visualization, have helped companies extract more from their investments and simultaneously reduce the number of workers needed on the mine site.

Although ROCs have helped mining operations modernize, they have a focus on limited use cases. Whether monitoring equipment, managing hauling operations, or ensuring safe blast operations, ROCs had a particular scope and function—often limited to a single site.



“Despite the growing focus on digital, many miners still lack an integrated approach to its implementation. This limits the value technology can bring to the business, and wastes money and time.”

EY

“[Top 10 business risks and opportunities for mining and metals in 2024](#),”

EY Insights, October 11, 2023

“IROCs are a milestone in the right direction,” says Wayne Nelson, Energy and Resources Industry Advisor at Microsoft. “They give you collective learnings across your assets and allow you to run simulations to understand the impact of different decisions. This is the direction that mature mining operations are heading.”

“It’s so simple and scalable. This is what I thought the future should be like—and we have it now.”

Frederik Hases

IT Manager, Boliden

See how Swedish mining company Boliden [enhanced its remote operations](#) to reduce the workload of maintaining and governing assets.



# Digital collaboration and training

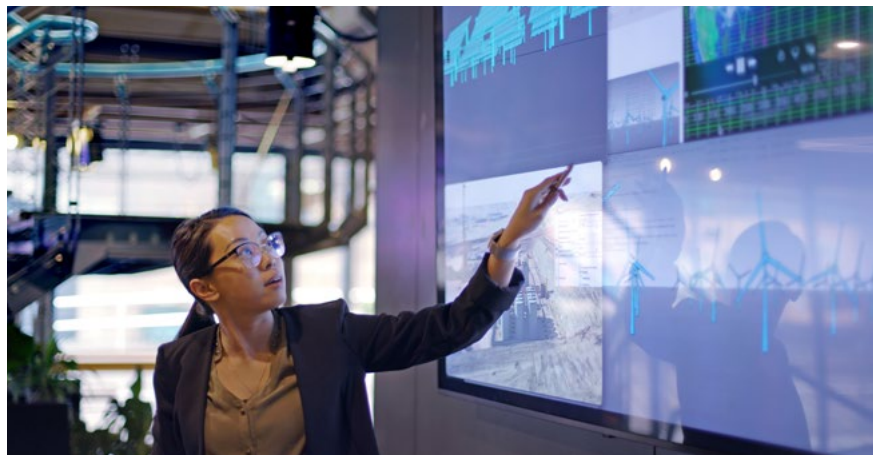
With remote operations on the rise, it's even more important to get technology in the hands of frontline workers to keep them connected to the rest of the team. According to Paul Mitchell, Global Mining and Metals Sector Leader at EY, the industrial metaverse helps mines go beyond integrating data and systems to better connect the people that make progress possible.

"People get scared that digital is going to remove jobs, but it's actually going to enhance jobs, make them safer and more interesting, and improve the livelihoods of people involved in the industry," says Mitchell.

Digital twins allow teams to manipulate 3D replicas so they can collaborate and design in virtual space. Engineers can simulate new ideas without using physical materials, speeding up product design and removing obstacles to innovation.

Even more urgent is addressing labor shortages and skill gaps that can throttle productivity. As the industry struggles to attract younger workers to mine sites that are far from home, the industrial metaverse holds the potential to reverse the trends and make mining careers more appealing.

"The mining industry is facing a huge challenge in hiring new employees," says Jessica Smith, Professor at Colorado School of Mines. "Most recent grads won't consider a career in mining. But changes in technology could make it easier for young people living in urban areas to work for a mine site in a rural region, which would make for more competitive hiring."



The industrial metaverse can also make remote training more immersive and meaningful with technologies like Microsoft HoloLens 2 and Microsoft Dynamics 365 Guides. Using the HoloLens device, equipped with a computer and transparent display, workers can see diagrams and instructions overlaid on their work environment. They can share their view with experts to get help on demand or get step-by-step directions with the help of generative AI. It all adds up to better communication, collaboration, and access to data when frontline workers need it most.

Rik Irons-Mclean, Chief Technology Officer, Enterprise Commercial, Australia and New Zealand at Microsoft, explains how the industrial metaverse adds an extra layer of support across the organization. "Mining operators have a finite set of resources, and they physically can't be everywhere. But with an IROC, you can bring remote experts into a virtual environment that increases your pool of accessible skills across every asset," he says.

"This technology can help us reduce the time and cost associated with regular travel, increase the speed of maintenance and new equipment deployment without compromising safety, and support greater inclusion and diversity."

Alex Bertram  
Digital Products Manager, BHP

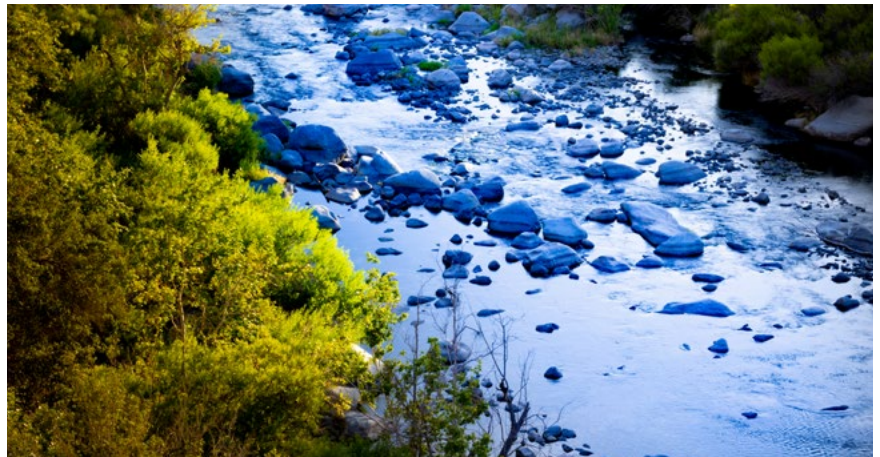
BHP helped its field workers get training and support from team members thousands of miles away. [Discover how the mining company used mixed reality to make it happen.](#)



# Beyond net zero

Optimizing operations and productivity is critical for protecting a mine's profitability, but, as Nelson explains, the imperative to meet climate goals is driving the industry to reimagine how sustainability factors into business.

"Sustainability is a muscle that has to be exercised across the business," says Nelson. "There are a lot of pressures converging at the moment, and although many companies are making sustainability commitments, they are going to miss their targets if they don't change their approaches. Today, people are looking at improving their operations from a profit base first, but sustainability needs to be embedded throughout the business. The industrial metaverse can help us simulate efficiencies and make sure the net effect of our changes is sustainable."



"If brought to scale, digital technologies could reduce emissions by up to 20% by 2050 in the three highest-emitting sectors: energy, materials, and mobility."

World Economic Forum

["Digital solutions can reduce global emissions by up to 20%. Here's how,"](#)

May 23, 2022



One of the mining industry's greatest opportunities to make the journey toward net zero is by achieving optimal productivity. When companies have the insights they need to make smarter choices, they can maximize outputs from equipment and mine sites and across the supply chain. Every optimization adds up, creating efficiencies that can ultimately help mining companies lower their emissions.

Some organizations are exploring horizons beyond net zero. "Major players are attempting to enhance our industry's brand. The perception that we don't help the environment impacts people's willingness to invest in this industry, even though the energy transition is dependent on mining," says Mitchell. "It's not enough for us to be net zero. Now we're looking at how to become net positive."

"With Copilot, we have eliminated so many manual tasks. We can do everything faster and better."

Sorus Urapepattanaphong

Senior Digital Technology Strategist, PTT Global Chemical (GC)

See why PTT Global Chemical considers Microsoft Copilot for Microsoft 365 to be a [net positive for its sustainability, operations, and service](#).



According to Mitchell, being net positive requires mining companies to go beyond their own operations to be stewards of biodiversity, water, gender equality, and more.

As we move toward a more sustainable future, businesses must also measure their impact on local ecosystems. These efforts can help operators maintain and strengthen their social license to operate in local communities. Some companies have made reforestation efforts or even remediated damage from old mines to show they are interested in more than land access—they want to develop meaningful partnerships with communities.

“We will be using things like radar, lidar, motion sensors, satellites, and drones to build an accurate, real-time view of a windfarm ... to see what’s working and what isn’t.”

Dennis Breugelmans

Director of Development for International Markets, SSE Renewables

SSE Renewables partnered with Microsoft and Avanade to develop [an ecological digital twin in the metaverse](#). Explore how SSE Renewables uses it to model cause and effect for its sustainability projects.



A photograph of three industrial workers in a construction or mining setting. They are wearing hard hats (one white, two yellow) and high-visibility safety vests (one yellow, two green). They are gathered around a table, looking at a laptop and some papers. The background is a blurred industrial site.

# Leading a people-first transformation

Although the industrial metaverse can give your organization powerful new capabilities, you'll need a people-first approach to realize its full potential. It's designed to empower people so they can do their best work, but technology alone won't close the gap between where you are and where you want to go. People need awareness, support, and shared vision to make new technologies an accepted part of their work culture.



It all starts with purpose. Driving transformation requires conviction from both senior leadership and the workforce. From the very top of the organization, mining executives need to align and socialize the “why” behind change. Teams want to feel like they are a part of the company’s future. That means articulating a clear vision of the future—and giving people line of sight into how their role contributes to the entire business.

“The people element is the biggest thing companies get wrong about transformation. Leaders need to help people understand the technology, the impact it could have, and teach them to use the tools so they make better decisions,” says Mitchell.

But getting people invested isn’t a decision; it’s a process. Workers need support as they adopt your vision and put it into practice. While they develop new processes and skills, companies need to reduce the friction of change. Otherwise, shifting roles can feel like a threat to employees’ job security rather than an investment in their professional development.

The future mining workforce is becoming proficient at these new ways of collaborating with technology and each other, and tools such as Microsoft Azure OpenAI Service and Copilot can help flatten the learning curve. Digital twins and extended reality are powerful sandboxes for enabling learning in a controlled setting, reducing risk before a wider deployment of solutions.

“Just as mining workers at large companies no longer work with picks and shovels, the workers of the future will not be driving trucks and loaders ... Rather, their skills will be in robotics, automation and data analytics.”<sup>3</sup>

PwC

*Mine 2023: 20th edition, June 2023*

“Using virtual reality and augmented reality can help train the workforce before technology even comes on site,” explains Key. From her perspective, the industrial metaverse is a win—for the mining companies that want to upskill their workforce quickly and for the employees who want to bring their best to their work. These technologies can increase the accessibility and inclusivity of training by adapting to each person’s unique needs and capabilities. Adds Key, “It’s a huge opportunity to help people feel comfortable with change. The industry also has an opportunity to make training uniquely personal for the individual. It can help companies make the most of each person’s strengths and see them beyond the limits of their role.”

Throughout the process, leaders will be the ones to develop and uphold the operating principles that keep people, data, technology, process, and culture aligned. The success of transitioning to the industrial metaverse rests squarely on a company’s ability to manage change through empathetic communication, clear documentation, and rigorous training. With all these elements, you can lead your people forward while creating tremendous value for all.



An aerial photograph of a mining operation. A wide, winding dirt road, colored a deep reddish-brown, curves through a rugged, rocky landscape. Three yellow mining trucks are visible on the road, moving from left to right. The surrounding terrain is a mix of reddish-brown earth and grey rock, with some sparse green vegetation in the lower-left corner.

# Partnering wisely for the journey ahead

The industrial metaverse's core strength is to finally break down data silos—but that isn't limited to the confines of your business. To achieve a sustainable future, the industry will need to break down silos everywhere they exist: in your company, across the value chain, and across your partnerships.

“The industry needs to mature as a community to get the full value out of transformation,” says Nelson.

In the past, mining companies, original equipment manufacturers (OEMs), and independent software vendors (ISVs) operated in separate worlds of data that were locked within their own systems. The industrial metaverse gives you and your partners the ability to securely unlock insights that were previously impossible.

“OEMs are starting to realize that the data inside a truck is only a small part of the story,” says Mitchell. “When you imagine how much better the context and support can be when you pair it with data from the processing plant, you can see the power of partnerships inside the industrial metaverse.”

Combining the latest technology with smart industry partnerships can help operators get past reactionary cost savings to drive long-term viability, even as the industry continues to change. Collaboration across academia, industry organizations, OEMs, ISVs, and other technology partners can help everyone move faster toward industry benchmarks and sustainability commitments. In short, it can make success simpler and more predictable.

Starting the process of transformation is easy, but keeping up the momentum is tough. It’s an ever-evolving journey to future-proof your industry—and your business by extension. According to Keay, that means choosing partners that are built to grow with you.

“You can’t expect to have all the in-house capabilities necessary to implement emerging technology,” says Keay.

She advocates for a collaborative approach to achieving maturity in your digital transformation. “Being able to co-design and partner with people who are experts is vital. If you want to make the future a reality, you’ll need a network of trusted advisors, not just for implementation but for ongoing optimization. Because, with the pace of change in the mining industry, you’ll have to continue to adapt.”





# Building a sustainable future, together

The mining industry has only just begun to reap the benefits of the industrial metaverse, but it's already paving a faster, more sustainable path to our shared vision of the future. If your company is ready to explore how the latest technology can help you secure your place as an industry leader, we're here to help.

The Microsoft Energy and Resources Industry team includes mining leaders who have been in your shoes and understand the complexities of your operational environment. Our experts and technology solutions are already helping companies like yours to exceed their commitments and overcome their most daunting challenges. So whether you're just beginning to explore the industrial metaverse or you're ready to advance your approach, our team is here to co-create your next step forward.

Learn more about [fueling an innovative future with Microsoft](#) >

Contact us at: [miningindustry@microsoft.com](mailto:miningindustry@microsoft.com) >



# Contributors



**Joseph Starwood**  
Worldwide Mining Industry Leader,  
Geologist, and Geophysicist, Microsoft



**Sue Key**  
Founder and Chair,  
Robotics Australia Group



**Rik Irons-Mclean**  
Chief Technology Officer, Enterprise Commercial,  
Australia and New Zealand, Microsoft



**Paul Mitchell**  
Global Mining and Metals Sector Leader,  
EY



**Wayne Nelson**  
Energy and Resources Industry Advisor,  
Microsoft



**Jessica Smith**  
Professor,  
Colorado School of Mines

## Sources

1. International Energy Agency, "[Critical Minerals Market Review 2023](#)," July 2023.
2. International Energy Agency, "[The Role of Critical Minerals in Clean Energy Transitions](#)," May 2021.
3. PwC, "[The Era of Reinvention](#)," *Mine 2023: 20th Edition*, June 2023.



©2024 Microsoft Corporation. All rights reserved. This document is provided "as-is." Information and views expressed in this document, including URLs and other Internet website references, may change without notice. You bear the risk of using it. This document does not provide you with any legal rights to any intellectual property in any Microsoft product.