Go With the Flow: Electrics for Futureproof Mines

E&MJ *examines the impact of modern mining processes and technologies on electrical infrastructure and considers some innovative designs*

By Carly Leonida, European Editor

The mining industry is responsible for 4%-6% of global CO_2 emissions and is facing significant environmental, social and governance (ESG) pressure from investors, regulators and downstream customers to reduce its footprint. As a result, companies are prioritizing sustainability and are taking steps to reduce their scope 1, 2, and 3 emissions. Most existing mining processes are already electrified to some degree, but significant areas of focus remain, such as scope 1 emissions from mobile vehicles (diesel or hybrid) used for hauling and material handling.

"The biggest trend we see today is the electrification of this fleet, with machine manufacturers modifying their vehicles to become electric, and some even fully autonomous," Eric Delaunay, technical expert and power system design consultant, leader of the Schneider Electric Mining Power System Competency Centre, told *E&MJ*.

"The impact on power system capacity of adding electric vehicles is relatively small, as many mine power systems are already electrified for processes like crushing, milling, grinding, flotation and conveying. And, for underground mines, hoisting, ventilation, and water pumping are significant electrical consumers. However, fleet electrification is expected to increase load requirements, and this means that access to a reliable and affordable source of electricity is vital."

Digitalization plays a crucial role in understanding mine power draw, quality and efficiency and allows optimized power systems to be designed. With 91% of mining and metals companies set to increase their investment in digitalization (according to a recent survey by EY), processing the impact of electrification on downtime and energy efficiency will become more transparent and savings more actionable.

"Modernization of industrial automation architectures and power systems is necessary as interoperability helps find efficiency options," Delaunay explained. "Customers now consider not only capital expenditure (CAPEX), but also aim to reduce energy costs and improve efficiency by looking at the process. Given the substantial electrical energy consumption of mining operations, optimizing power system design, architecture, and operations is important to reduce electrical energy consumption and losses in perspective of the process for achieving overall energy efficiency goals."

Electrification requires new mine designs that make provision for future developments and technologies such as hybrid electric trucks that run on trolley systems, and battery equipment storage systems. (Image: ABB)

Optimization for Quality and Safety

While a focus on CAPEX reduction may result in a specific power system design, optimizing that design for energy efficiency can also be achieved using input data from processes, such as ore hardness which can influence grinding and residence time. This optimization is easily achievable in new mines or can be done through tweaking existing processes. However, in existing mines, the architecture and power system are already established, so improving performance relies mainly on process optimization or improving electrical power quality.

Leveraging renewables through microgrids is another way to ensure the reliability and availability of energy, especially in locations where the grid is not available or unreliable. However, when local power generation may not be possible or is not the best solution to meet mine electrical demand, a Power Purchase Agreement (PPA) can provide both CO_2-free energy and limited, calculated risk on electricity pricing impact on cost-per-ton of ore.

Power quality plays a significant role in mine energy efficiency, as poor electrical quality leads to increased losses in the system and can reduces equipment lifespans. Identifying and mitigating power quality issues can be challenging due to their hidden nature and difficulty in interpreting measurements and understanding their impact on production and energy consumption.

Delaunay said: "Digital tools and edge sensors combined aid in analyzing power systems, allowing operators to check their power quality without downtime, and in identifying areas where a site can

improve. These tools are useful for creating multi-variable models, simulating the existing system and can help in identifying solutions to mitigate persistent power quality problems, or simply improve existing power quality.

"Improving power quality results in reduced losses through cables, transformers, capacitors, and connected equipment — in other words, making better use of "the copper mines have already invested in." Leveraging digital tools can enhance the overall energy efficiency of mining operations, even to the extent of significantly increasing overall production."

Of course, safety is paramount due to the risks associated with electrical infrastructure, including the potential for electrical fires and risks for operators e.g., electrocution and burns due to arc flash. But fortunately, there have been significant improvements in this area too.

"Mining operations have always had a sensible approach to safety," said Delaunay. "However, given that some mines are a century old and electrical equipment has limited lifecycles, there comes a point where replacements are necessary. During these replacement and maintenance activities, there's an opportunity to upgrade to equipment with enhanced safety features, like internal arc-withstand equipment and arc flash detection solutions. There are also earthed screen insulation, energy reduction maintenance settings, continuous thermal monitoring, and remote control operation. This provides enough reason to involve specialists."

Flexible Designs for Future Needs

Safer and more advanced technologies must be incorporated into greenfield mines from the get-go, particularly electrical equipment that's resistant to environmental factors, such as dirt. New technologies play a significant role in the lifespan of a mine and are crucial in the design of mine power systems to ensure future-proof operations. It's also worth remembering that mines are dynamic environments and particularly underground, where there can be thousands of kilometers of galleries, the location of substations and power systems must be adjustable and mobile power equipment considered.

Delaunay explained: "When designing power systems for mines, it's essential to prioritize this feature of relocating different loads and potentially moving substations for overall efficiency and reach. A plan should be in place to accommodate future stages of expansion and the integration of additional electrical vehicles. The power system architecture should be designed in a way that allows for easy extensions and integration, minimizing impacts on day-to-day operations. Having a specific architecture in place for these extensions will facilitate efficient management of the system architecture and loading as a result."

Panoramic view of the Copper Mountain site in British Columbia, Canada. ABB's Ability eMine trolley system reduced CO_2 emissions on part of the haul route by 90%. (Photo: ABB)

Schneider Electric is accelerating the transition to 'green sustainable processes' through energy strategy setting, consulting and digitally integrated solutions. The company is combining unified electrification and advanced automation strategies, leveraging digital energy, energy storage systems (ESS), renewables and microgrids and industry control system smarts for optimized operational efficiency.

"In the area of software and analytics, we have ETAP — a leading software platform for electrical power systems modeling and simulation — that can suggest various scenarios for a site or enterprise," Delaunay said. "Then there is the Schneider Electric EcoStruxure Microgrid Advisor for the interoperability of power sources in front or within the mine fence. With these systems, customers can make the most of microgrids and utility level generation on site, but also their backup systems. This helps them achieve a good balance between productivity and sustainability goals in the short, medium and long-term."

EcoStruxure Power Advisor is a cloud-based diagnostic service designed to improve power system reliability based on power quality. Using analytics from a mine's power network, Schneider Electric can find, prioritize, and recommend ways to resolve problems impacting system performance.

ABB's New Five-point Mine Electrification Plan

According to ABB's Mehrzad Ashnagaran and Marcos Hillal, a phased approach to mine electrification, inclusive of strong collaboration and early involvement of all partners in pre-planning, plus future-proof mine design and equipment are key to successful electrification.

The company has developed a new action plan that sets out a strategic roadmap to decarbonizing operations for any underground or open-pit mine from pit to port. This comprises five steps towards complete plant electrification across hauling operations, and power distribution and management.

Mehrzad Ashnagaran, Global Product Line Manager for Electrification and Composite Plants, explained: "Creating innovative business models and fostering collaboration between technology providers, OEMs and mining companies at the earliest stage in the project lifecycle is the most effective way to de-risk process plant development. This leads to improved electrification, digitalization and production efficiency, as well as reduced energy usage and carbon emissions, and CAPEX and OPEX savings."

The Charge On Innovation Challenge is an example of this. Launched by BHP, Rio

FastCharge is part of ABB Ability eMine, a solution that integrates digital applications to monitor, control and optimize energy usage. (Photo: ABB)

Tinto and Vale, the global initiative seeks to accelerate progress towards zero-emission mining vehicle fleets by commercializing solutions for charging large electric haul trucks. ABB's shortlisted entry, ABB eMine FastCharge, is set to be the fastest and only fully automated charging system for trucks offering up to 600kW of power. It follows open industry standards, part of ABB's strategy to ensure current and future electrification solutions are compatible with existing OEM equipment.

"Creating this kind of open communication standard enables multi-vendor integration of both mobile and fixed assets throughout the mine for real-time data acquisition, aggregated via one platform, so that the operator is able to gather data on the location and charging status of each individual vehicle," said Ashnagaran.

FastCharge is part of ABB Ability eMine, which streamlines electrification processes using hybrid power solutions and integrated digital applications that monitor, control and optimize energy usage. Combined with ABB's portfolio of motor, drive, generator and power control technologies, these solutions can help fast-track the transition from diesel-powered equipment to all-electric mines.

Electrification also requires new mine designs that make provision for future developments such as hybrid electric trucks that run on trolley systems, and battery equipment storage systems (BESS). At the same time, engineers must design fully optimized power systems that ensure a constant, reliable supply of renewable power to mine operations, either directly from the grid or on-site. Renewable energy can be intermittent, so new solutions are required to ensure power is integrated with management and storage systems that can guarantee an uninterrupted supply 24/7.

"Again, this is about standardization," Marcos Hillal, Global Product Line Manager, Automation and Digital at ABB, told *E&MJ*. "Mine design should not only be about vertical integration, but also ensuring that all assets are connected horizontally, so the concept and philosophy used to operate the grinding systems, for example, should also apply to power distribution. This fully integrated model will reduce operating costs for operators while also ensuring the same level of functionality and production."

ABB's mine electrification plan also emphasises investment in fit-for-purpose, tailored solutions that align with an individual mine's efficiency targets. For example, the ABB Ability eMine trolley system was installed at the Copper Mountain mine in Canada and reduced CO_2 emissions by 90% on the trolley line.

Hillal said: "Our approach to equipment lifecycle management is designed to ensure that a mine's technologies and production processes continue to address critical environmental challenges, from installation to commissioning.

"However, lifecycle management goes beyond maintaining equipment. Mine power requirements will increase as operations introduce more electrification and expand production to keep up with future demand for metals and minerals, despite the removal of fossil fuels. This power consumption makes digital and automated control systems that can track and manage energy usage and recharging even more important."

Today, lifecycle management also means employing remote monitoring to keep production up and running and advanced digital mining services to collect and analyze asset and operational data. This allows potential issues to be identified and mitigated through remote services, predictive maintenance, and upgrades and retrofits.

"Existing mines are not necessarily readymade to work and be compatible with a system that is fully electrified, and technology vendors and OEMS must recognize that each individual mining customer is at a different stage in their digital journey," Hillal concluded. "The transition to all-electric mines must also be supported by the transformation of processes and people — something that is often overlooked."

Pratly Launches Flameproof Ex d Envirobox Junction Box

In May, Pratley, launched the new Flameproof Ex d Envirobox which it describes as "the world's first polymeric, corrosion-resistant, direct-entry, flameproof junction box."

Flameproof equipment is designed to prevent internal ignition within a flammable atmosphere from transmitting outside the protective enclosure. However, all traditional direct-entry flameproof junction boxes made from steel, cast iron or aluminium materials can be prone to corrosion over time.

The Flameproof Ex d Envirobox junction box is made from a specially formulated polymer designed to withstand severe environmental conditions. This makes it suitable for use in both surface and underground mines. The Flameproof Ex d Envirobox is fully certified to SANS, EN and IECEx standards for applications with an ambient temperature range of -40°C to +55°C.

Sven Breedt, Electrical Research & Development Manager at Pratley, said: "Over a decade's worth of research and development went into this junction box. It's a world first, and I see it marking the future of electrical termination products for explosive atmospheres."

Pratley's Flameproof Ex d Envirobox. (Photo: Pratley)