Integrating battery electric vehicles constitutes the final stage in the journey to all-electric mines, helping operators to reduce carbon dioxide emissions and improve efficiency. Mehrzad Ashnagaran and Nic Beutler, ABB, explain how partnering with trusted technology and equipment vendors is the key to success.

The mining sector is undergoing a radical transformation, driven by digitalisation and electrification. Digital technologies, such as the Industrial Internet of Things, artificial intelligence and data analytics, now give mine operators visualisation of the entire production chain: improving productivity and profitability; reducing downtime and maintenance; and informing smarter, data-driven business decisions.

In tandem, the vision of the integrated, all-electric mine – one that incorporates optimal design and operations for more efficient, sustainable energy and resource consumption – is closer to becoming a reality. Central to this goal is eliminating diesel from haulage trucks, the largest source of carbon dioxide (CO₂) emissions in many opencast and underground mines, by shifting to hybrid and fully electric trucks.

Why electrify?
ABB believes that electrification is a ‘must-have’ for mining companies, compared to ‘business as usual’. The industry is responsible for 4 – 7% of global greenhouse gas emissions, and the onus is on operators to reduce their carbon footprint to comply with increasingly strict government environmental legislation, in line with the goals enshrined in the 2015 Paris Agreement.

Failure to do so can result in financial penalties, the loss of competitive advantage, and reputational damage. Mining operators that remain behind the curve when it comes to sustainability, health, safety, and the environment risk losing the backing of their board and investors, may not be permitted to work in certain jurisdictions, and could even lose their licence to operate.

In certain countries, carbon taxes must already be factored into OPEX calculations, as governments and industry make a compelling business case for electric mines. This shift is more advanced in underground mines, where the electrification of truck fleets has already become reality, and solutions, such as ventilation on demand, are established innovations that significantly reduce energy consumption, as well as provide a safer, more amenable working environment.

The industry is part of the problem of climate change. However, by providing commodities such as copper for use in wind turbines and lithium for the batteries in electric vehicles – both of which have a pivotal role to play in the global transition from fossil fuels to renewables – in a way that minimises energy usage, resource consumption, and CO₂ footprint, mining is also part of the solution.

The three pillars of electrification
ABB’s electrical, control, and instrumentation (EC&I) business has, for almost half a century, been a leader in mine electrification. By leveraging the technology within its portfolio and incorporating it along with the latest innovations in mine engineering and design, ABB is helping to create fit-for-purpose solutions that minimise CO₂, improve safety, and, ultimately, boost profitability.

ABB’s approach is built around three pillars:
- Electrification.
- Automation and digitalisation.
Being the key technical supplier in partnership with other original equipment manufacturers (OEMs).

What are the design requirements of electrified mines? Do they require centralised or decentralised storage systems? What are the optimum grid solutions and how can they incorporate the flexible loading of mobile equipment and integration of renewables?

The first step on this journey is to develop existing equipment and components so they are digitally enabled, and then connect them in a smart way with the flexibility to cope with supply and demand.

Open communication standards and multi-vendor integration are key to effective automation and digitalisation. This means developing a single automation platform that can communicate with all the different mine assets, mobile and fixed, as opposed to a standalone architecture for each individual system. In addition, real-time data acquisition and visualisation allows the operator to make smart decisions, and data analysis using advanced algorithms allows them to assess the state of the mine operation.

How can new technologies be embedded effectively? By putting in the third pillar, alliances of key technical suppliers and OEMs, each with their own domain expertise, can jointly develop solutions that benefit the customer, rather than one party being responsible for the whole project scope.

This is increasingly becoming the working model of choice for electrification projects, particularly when it comes to integrating a mobile fleet. At Boliden’s Aitik copper mine in Sweden, for example, ABB successfully collaborated with a vehicle supplier (a third-party OEM) – bringing together two entities which traditionally would not have worked together – to install a trolley assist line for hybrid trucks.

ABB recently signed a memorandum of understanding with Hitachi Construction Machinery to explore opportunities to apply ABB’s electrification, automation, and digital solutions to mining trucks and excavators provided by Hitachi. Together, the two companies hope to present a combined solution to the market that will help mining customers achieve net-zero emissions from their operations.

ABB is also working with other OEMs to create a platform for early-stage collaboration; for example, to explore the potential of incorporating batteries into the trolley assist mix at opencast mines.

Furthermore, ABB is collaborating on electrification retrofit projects, including converting a diesel-powered Western Star 4900 XD truck with MEDATech Engineering and Tardif.

**Six ingredients for effective integration**

ABB has identified six essential ingredients for the effective integration of battery electric vehicles into an existing mining operation: interoperability, mobility/flexibility, energy management, connection interface, trolley and charger technology, and favourable process and mine design.

**Interoperability**

Mine fleets comprise vehicles from multiple vendors. ABB charging infrastructure follows open standards, such as CCS and OPPCharge, in order to remain vendor-agnostic,
meaning that it can be used across all vehicle types and OEMs. This allows the customer to make a one-off investment and maximise the uptime, productivity, and return on investment of every piece of charging equipment.

**Mobility/flexibility**
Strategically placing charging points throughout the mine means trucks remain charged for longer, optimising their usage and overall mine productivity, and avoiding the need for additional traming routes and vehicles. These points of charge need to be able to adapt to changes in the mine’s design throughout the lifetime of the mine.

**Energy management**
Integrating battery electric vehicles into mines, the final stage of the electrification journey, means energy load requirements are much more volatile. While renewables are becoming more relevant, in particular for remote sites, they do impose additional constraints. Smart planning of grid infrastructure and battery energy storage systems, combined with mine production forecasting, can be used to minimise load peaks and address possible volatility on the generation side.

**Connection interface**
Ruggedised and mine-approved automated connection interfaces must be designed to withstand the harsh environmental conditions in many mines, as well as the high-power demands of large mining trucks. This requires open mechanical and electrical standards, as well as effective collaboration with vehicle suppliers.

**Trolley and charging infrastructure**
ABB is building on existing solutions and long-lasting experience related to trolley and charging infrastructure for battery electric mining vehicles. Again, these must be robust enough for the mining environment and capable of matching the high power demands of battery electric trucks, in order to ensure maximum vehicle uptime.

**Favourable process and mine design**
Adopting new technologies will change how mines and mining assets are operated. Does the civil infrastructure and operational schedule need to be changed in order to meet the demands of these battery electric vehicles, for example? Early-stage design thinking and planning is crucial to success.

**Case study: Copper Mountain, Canada**
ABB is currently working with Copper Mountain Mining to provide a complete haul truck trolley assist solution for its Copper Mountain mine, located near Princeton, British Columbia. The conventional opencast operation produces approximately 45 000 tpy of copper equivalent.

ABB is responsible for all the off-truck trolley assist infrastructure – including the overhead catenary system (OCS) design and a rectifier substation, providing in excess of 12 MW of direct current power – as well as the engineering, project and construction management, equipment supply, and system commissioning.

The trolley control system can provide connectivity to the existing distributed control system automation platform, allowing for seamless integration and monitoring of trolley operations and energy consumption.

It is estimated that Copper Mountain will reduce emissions by 7% during the first phase of the project, and the goal is a 50% reduction in CO₂ during the next 5 – 7 years. Other benefits include improved efficiency; each electric-drive truck will be fitted with a pantograph to receive external electric power, meaning they will run faster when connected to the trolley system, use less fuel, and require less maintenance.

ABB is collaborating directly with Copper Mountain and the truck OEM to deploy the 1 km proof-of-concept. This approach encompasses the entire ‘grid-to-wheel’ process, starting with: the power distribution via the rectifier substation, design and execution of the overhead line, installation and civil work, and the creation of the surrounding infrastructure.

In this way, if future retrofitting takes place or an OEM supplies a new generation of hybrid trucks, ABB can use its electrification expertise to create and coordinate a complete integrated solution.

ABB has already enjoyed success with trolley assist solutions at the aforementioned Aitik mine, for Boliden. The company has designed, delivered and commissioned an effective electrical infrastructure to power several mine trucks. The lane is approximately 700 m and is expected to save approximately 830 m³/y of diesel.

**The journey to electrification**
Electrification is well underway across most of the mining chain. Electrifying the last puzzle piece by incorporating battery electric vehicles is still in its infancy and will require mining companies to adopt new technologies and working practices, in addition to addressing new challenges with regards to planning, fleet management and skill sets.

The benefits are clear, however. In addition to complying with regulations aimed at reducing CO₂ emissions and improving workplace safety, using diesel-electric trucks on trolley assist lines, for example, is proven to boost speed-on-grade for greater throughput, enable more efficient and proactive maintenance, and reduce heavy vehicle use for better fleet availability and longevity.

Reducing emissions through electrification also makes good business sense. Electricity is becoming more cost competitive, and premiums are being offered by energy suppliers to incentivise its use. This, coupled with taxes on emissions and the removal of tax advantages from diesel, means that mining companies can no longer afford to be behind the curve when it comes to electrification.

Partnering with a trusted technology provider with proven domain expertise, such as ABB, is key to: incorporating battery electric vehicles into mines as part of the industry’s wider digital transformation, driving sustainability, minimising carbon footprint, and optimising both production and profitability. GMR