

MINING'S ELECTRIC REVOLUTION

Marc Melkonian, Aramine, France, considers the many benefits of adopting battery-powered vehicles for the mining industry's future.

A number of trends have shaken up the mining sector in recent years, with the dilemma of how to maintain or even increase productivity while adapting to stringent environmental requirements. As mining companies look for ways to limit their environmental impact, it is necessary to look at one of the main sources of CO₂ emissions: the use of diesel to power machinery engines.

For a long time, underground mines were able to operate solely on diesel vehicles, a reliable energy that provided unrivalled autonomy. Over the last few years, however, environmental and worker health concerns, among other factors, have changed the situation. Is it possible to use another form of energy to power the machines?

The use of diesel requires constant attention to air quality for workers, a particularly difficult challenge in a confined environment such as underground mines. Several exhaust air filtration solutions have been developed, including catalytic converters, particle filters, fuel thinners, and more. They have improved working conditions, but have also increased maintenance requirements and machine costs.



From cable reel to batteries

It is in narrow vein mines, which use smaller than average machines, that technological innovations have made it possible to offer unprecedented machines. The first step was taken some 30 years ago with the introduction of the first electric machines with a cable reel.

All that is needed is connecting the machine to the power grid to run it continuously, and thus maintain high productivity without any pollution. However, this cable, which is sometimes hundreds of metres long and permanently in the space between the machine and the electrical socket, is not the most practical to handle. Not to mention that it is occasionally immersed in water, which can be dangerous as these machines need a lot of electrical power to operate. However, the savings in ventilation costs and the reduction in exhaust gases in the galleries justify these limits.

How do you offer an alternative to diesel, while making the machine autonomous by removing the cable that connects it to the electricity grid? 10 years ago, the market opened up to a new innovation: battery-powered electric mining machines.

French manufacturer Aramine launched its L140B mini loader, based on a simple principle: the rear of the machine can be detached, thanks to an innovative system, and houses the battery packs, the battery charger, and the necessary electronics. This assembly, called the 'battery energy module', can be replaced in less than five minutes using a hoist, and then charged outside the machine.



Figure 1. The L130E electric mining loader, with the cable reel at the back.



Figure 2. The L140B battery-powered mining loader, with a fully removable battery energy module.

Many advantages

Mining operators are looking favourably on the arrival of these innovative products on the market, as they present numerous advantages. In particular, they offer mine workers more comfortable working conditions: the machines are less noisy, they lower ambient temperature by 80% by removing the engine and hydrostatic transmission, and they avoid CO₂ emissions, thus reducing ventilation costs. Above all, they provide unlimited autonomy, as the machine can run on a second battery while the first is recharging.

Although the initial costs of battery-powered mining vehicles may be higher than those of diesel machines, the long-term operational savings offer a compelling argument. Electric motors generally require less maintenance than their diesel counterparts, reducing downtime and increasing equipment availability.

Additionally, the cost of purchasing fuel, a major expense in mining operations, is eliminated. Mines can thus make substantial savings on their operating budgets, helping to offset the higher initial costs of electric equipment.

Proven reliability

The development of the technology has had to go hand in hand with a change in mentality, as concerns have been expressed about the reliability of these new machines. Today, each machine manufacturer has developed its own battery-powered machine with its own technology.

Some have opted for fast recharging. However, this technology requires the installation of a large cooling system and a powerful electrical network to recharge the battery, which implies high costs and maintenance. Others have chosen to offer a battery replacement system with a powerful external charger. However, this solution requires dedicated recharging points. Aramine has opted for an on-board charger, with the rear of the machine completely detachable, allowing the battery to be recharged close to any electrical outlet.

Now, 10 years after the first battery-powered machines were introduced, reliability has been proven, and mining companies are making increasing use of these tried and tested technologies.

New challenges ahead

However, the transition to battery-powered vehicles is not without its challenges. Mines are often located in difficult environments, characterised by extreme temperatures, dusty conditions, and rugged terrain. These conditions can put pressure on battery performance. Low temperatures can reduce battery efficiency, affecting vehicle range and power. Engineers therefore need to design battery systems capable of operating reliably in hostile environments, ensuring their resistance to temperature variations and mechanical stress.

Initially proposed for small vehicles, rather than for narrow vein mines, battery-powered machine technology is now being developed for larger and larger machines, thanks to batteries that are increasingly powerful while remaining compact. In 2015, for example, Aramine launched its first electric mini loader, the L140B, with a tractive effort of 3.5 t.

In 2024, the manufacturer is due to launch its L440B loader, this time with a tractive effort of 13 t.

What about long distances?

Mining operators, seeing the efficiency and many advantages of battery-powered machines, are tempted to gradually renew their entire range of machines, including the largest trucks. At the moment, however, manufacturers are obliged to wait for the emergence of more efficient batteries before introducing battery-powered trucks.

Batteries, despite their compact size, can be heavy, which can affect the payload capacity of mining vehicles. Mines often operate vehicles with high load capacities, and the additional weight of batteries can limit this capacity. Designers need to strike a balance between payload

capacity and battery size to ensure optimum operational efficiency.

Battery autonomy must be significant to ensure mine productivity, and it is currently insufficient for these types of large, powerful vehicles that operate over long distances. For larger machines, it is important to ask the question of profitability, i.e. cost versus productivity.

In this case, as with private cars, it is tempting to opt for something in between: a hybrid solution, such as a truck using both batteries and a diesel engine. Unfortunately, the use of these two energy sources means that it is not possible to build a vehicle that is both powerful and compact enough to meet the requirements of mining companies.

Another solution would be to use both a trolley for long distances and a battery-powered machine for short distances, but this would require an expensive fixed installation.

Although the mining industry is embracing the transition to battery-powered vehicles, it is important to note that this evolution is generally taking place gradually. Mines are opting for a hybrid approach, integrating battery-electric vehicles into their existing fleets while retaining some diesel equipment. This strategy enables a smooth transition, minimising risks and disruption to operations.



Figure 3. The battery energy module can be replaced in less than 5 minutes using a hoist.



Figure 4. The L440B battery-powered mining loader, Aramine's new machine launching in 2024.

Social impact

The adoption of battery-powered vehicles in the mining industry also has positive social implications. Reducing its carbon footprint helps to improve the image of the mining industry, often criticised for its negative environmental impacts. This can strengthen relations with local communities and stakeholders, fostering wider acceptance of mining activity.

In addition, the transition to cleaner technologies is creating new employment opportunities in the renewable energy and battery technology sectors. Workers in the mining sector can benefit from training programmes to acquire the skills needed to maintain and operate the new equipment.

An ever more innovative future awaits

For now, therefore, diesel-powered machines are still essential for certain activities, particularly the most energy-intensive operations, such as moving machinery over long distances. As they wait for high-performance batteries suitable for large trucks, manufacturers are innovating with diesel engines that pollute much less than their predecessors.

By embracing this electric revolution, the mining industry can not only improve its own profitability, but also make a significant contribution to the global transition to a more sustainable economy. Battery-powered vehicles are reshaping the face of the mining industry, offering a promising glimpse into a future where natural resources are extracted in a more environmentally-friendly way. The future of the mining industry looks set to be innovative and increasingly carbon-free. **GMR**