

BEV Technology: What's Next?

E&MJ presents a roundup of key product and technology launches in the battery electric space and asks some OEMs what they have in store for 2021

By Carly Leonida, European Editor



The new battery-powered SS5 shotcrete sprayer and TM3 tumbler are put through their paces at the MacLean test mine. (Photo: MacLean Engineering/Mining Industrial Photographer)

In addition to much discussion and various battery electric vehicle (BEV) adoption announcements, 2020 also saw a record number of new product launches and technology tweaks. Many OEMs have further developments planned for this year and a few key players joined *E&MJ* to discuss their R&D work...

Aramine Adds Quick Replacement System

During 2020, Aramine focused on developing new tools that ease the usage of battery technologies.

"Many of our customers have asked us to provide a simple solution to safely change batteries," Aramine Co-president Marc Melkonian said. "That is why we have created a charging station in fixed or mobile versions with a hydraulic crane and a radio control that is easy to use.

"The mobile charging station requires very little space and does not need a special setup in the mine. This station also allows you to move batteries from one face to the other but can also help move other equipment."

Another recent development is the new Quick Replacement System (QRS)

that allows batteries to be changed in and out of the miniLoader L140B in less than 15 minutes. Aramine said it is the first OEM to launch this type of battery changing system for underground mining.

"Changing the battery is stress-free, doesn't require a lot of equipment, and can be done quickly. With the QRS version, it's possible to have only one machine running in the mine," Audrey Beurnier, Aramine communication and marketing manager, explained.

The QRS is available as an optional extra on new miniLoader L140Bs and can be retrofitted to operational machines with a fixed frame thanks to a spare kit. Because the battery charger is located on each battery module, the replacement can be done anywhere as long as there is a 220V or 380V electrical plug.

"In 2017, the Aramine design office carried out research and development studies on customer feedback requesting long-lasting productivity," Melkonian said. "The aim was to achieve unlimited machine operation in mines with safe, easy and quick battery replacement by the operator.

"Unlimited autonomy or quick battery charging is usually achieved with complex

systems like battery cooling and high-power chargers. We considered these features not applicable for underground mining and decided to go for the simple, safe and efficient QRS. Changing the battery is now faster than filling the fuel tank."

To use the QRS, mines only require one or more additional battery modules — while one module charges, the other powers the machine and vice versa, allowing continuous machine operation. A simple mechanism ensures self-guiding and locking of the battery module on the machine.

"Our R&D department has worked hard to reorganize all the components inside the machine and selected an extremely reliable and safe connection system with maximum power in order to keep the strength of the Aramine miniLoader L140B," Beurnier added.

Will the system be rolled out to other Aramine models in the near future? *E&MJ* asked.

"Aramine is always innovating and in 2020 we launched a new diesel 3.5 tonne loader, the L350D," Melkonian said. "There is already a battery-powered version under development, the L350B. This will feature a similar QRS system to the miniLoader L140B and will also use the same charging station and crane."

Aramine plans to debut the L350B at the next MINExpo event, which is set to be held in Las Vegas in September.

Like its diesel counterpart, the L350B will feature a ROPS/FOPS approved open or enclosed cabin, a steering and boom-up locking device, wheel chocks, audio-visual reverse alarm, easy and anti-skid access, and an emergency stop as well as an automation ready CANBUS system.

The frame has been designed for long life and easy maintenance and, overall, the compact design makes the L350B ideal for narrow vein operations.

From Loaders to Drill Rigs...

"The next step for Aramine is to develop the perfect drilling complement for

the miniLoader L140B,” Melkonian said. “We’ve developed a very reliable battery powered system for the L140B, and we will rely on this technology to develop our first battery-powered drill rig.”

The DM901HBE will use battery technology to move the arm of the drifter and a tethered source of electricity for drilling. The battery pack will be fixed (no QRS system included) as the batteries will recharge themselves autonomously during drilling.

The new drill rig will be adaptable to each mine’s requirements and the drifter can be specified by the customer. However, Aramine recommends as standard the Epiroc RR14 drifter and feed.

“Nowadays, there is a real need for zero emission machines in underground mines and particularly in narrow vein operations,” Melkonian said. “This version is already eagerly awaited by our customers around the world, especially those in South America, Australia and Europe.

“We have always been very concerned about environmental issues and health and safety,” he added. “This is why battery powered machines are a must-have in our industry, to reduce ventilation and infrastructure costs and improve the air quality in mines to protect the workers. As Aramine is making it simple to adopt and use daily, battery powered technology will have a big place in the future of mining.”

Epiroc Rigs Shine at Kittilä

In Finland, Agnico Eagle’s Kittilä gold mine provided a testing ground for Epiroc’s next generation BEVs as part of the European Union-funded SIMS project. The project, which came to a close in April 2020, lasted three years and was tasked



The miniLoader L140B QRS5 — the Quick Replacement System allows the battery to be changed out in less than 15 minutes. (Photo: Aramine)

with developing smart and environmentally friendly systems for the mining industry.

Following the tests, the mine decided to purchase two Boltec E battery-powered bolting rigs. The first unit arrived at Kittilä in early November, and the second a few weeks later.

Jari Kolehmainen, Kittilä’s production manager, said the team’s first impressions were very positive.

“The performance of the machines is at least at the same level as that of diesel machines. Productivity has improved with the development of equipment,” he commented. “The change in air quality [underground] is clear. In the future, we want to reduce our carbon footprint and move toward zero-emission technology, as well as move forward in well-being at work. The SIMS pro-

ject showed that battery technology has made great leaps forward.”

The mine has had to reconfigure its electrical infrastructure to accommodate the new machines and a battery replacement bay has been added to allow for swapping but otherwise, no other special requirements were needed.

The Kittilä team is also keen to introduce other new technologies in addition to battery-powered equipment. A remote-control room has been added to the office, from which several machines are controlled simultaneously by two operators since the beginning of October.

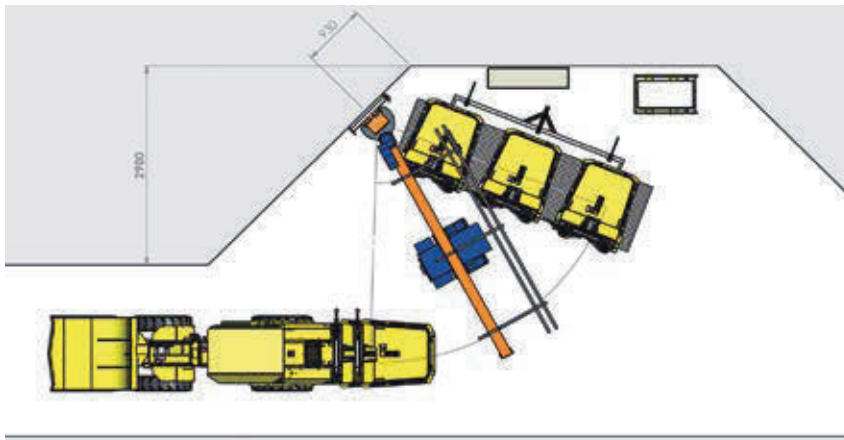
First Batteries as a Service

In July, Epiroc also announced it had signed the world’s first Batteries as a Service (BaaS) agreement with Vale in Canada.

With BaaS, Epiroc works directly with the customer to define a battery plan that suits the needs of their operation. The lifespan is guaranteed, and the battery status is monitored to ensure predictive maintenance with reduced downtime. If a customer wants to increase or decrease their capacity, they can adjust their plan and the service will be tailored to meet their requirements.

In line with its keen focus on sustainability and circularity, Epiroc will remove old batteries from site and replace them with new. The older batteries are then used for secondary applications and are recycled at the end of the process.

“A key component to the success of this offering is the flexibility it allows our cus-



The charging station — tunnel layout for Aramine’s battery-electric L140B loader. (Photo: Aramine)



The new LH518B, Sandvik's first 18-t battery-electric loader. (Photo: Sandvik)

tomers. We take ownership of the battery itself and automatically replace and update the units as needed, which means the mine site can breathe easier and continue to focus on heightened production," Shawn Samuels, product manager, Rocvolt, Epiroc Canada, commented on the announcement.

Additionally, Epiroc will be providing Vale with 10 BEVs for two of its Canadian mine sites. These include four Scooptram ST14 loaders, two Boomer M2C drill rigs, two Boltec MC bolting rigs and two Minetruck MT42 trucks.

To complement the new battery fleet, Vale will also be adding three of Epiroc's charging cabinets and seven charging posts for equipment support. Delivery will be completed in Q1 this year.

Ann-Sofie Andersson, global manager for branding and communication, said Epiroc aims to offer battery-electric versions of its entire product portfolio by 2025. The battery system Epiroc uses is modular and designed to be scalable for larger and smaller products as well as for new applications.

"Our current offering includes 7-t, 10-t and 14-t loaders; 20-t and 42-t trucks; and a range of (currently 11 models) battery-electric mid-sized drilling equipment including face drilling, production drilling and rock reinforcement rigs," she said. "We also have a 4-t loader specifically for the Chinese market."

In addition to the Kittilä and Vale projects mentioned above, Epiroc is also testing an 18-t battery-electric loader at the LKAB-led Sustainable Underground Mining (SUM) project.

MacLean: New Batteries, New Machines

MacLean Engineering already offers battery-electric versions of many of its underground hard-rock equipment models, and the team is currently working on battery

technologies that will extend or improve their performance. First up is a new battery chiller that will allow MacLean BEVs to operate in hotter conditions.

"We'll be releasing that in 2021, particularly with the Australian and African markets in mind," said Maarten van Koppen, product manager for mine operations at MacLean.

The team is also working on additional battery options, which are currently being tested and are planned for launch later this year.

"What we've seen over the past couple of years is that one battery size for all machines and all applications is not the most efficient way to put these machines to work," van Koppen said. "So, we're working on options, based on the same chemistry we've been using since 2016, but which provide both lower and higher energy capacities to the market."

"That's important, for example, on sprayers or bolters, which can plug in and charge their batteries whilst operating. They don't typically run far so putting a large battery on them doesn't make sense. Conversely, concrete trucks that drive up and down the ramp, could probably benefit from a larger battery. For us to continue with only one battery solution didn't make sense anymore. We saw that we needed to provide more granularity in that, and it's going really well."

MacLean was outfitting one of its machines with a new battery when the team spoke to *E&MJ* in December with testing set for early January.

MacLean also has plenty of machine launches in the pipeline for 2021, including a road grader and a new shotcrete sprayer-tumbler pairing.

"The road grader is primarily designed as an electric machine, although we'll also be offering it in diesel," van Koppen said. "To our knowledge, it's one of the first

purpose-designed underground hard-rock graders that falls into the heavier size class.

"We're also evaluating an articulated, heavy-duty forklift with multiple attachments like tire handlers, etc."

The new battery-powered SS5 shotcrete sprayer and TM3 tumbler will also debut in early 2021. Product manager, shotcrete equipment, Jonathan Lavallee, took over to tell *E&MJ* more.

"The SS5 prototype is currently at our Magill Street test mine and R&D facility in Sudbury going through the final performance checks," he said. "That's going really well."

Key features include a new pump that has been designed specifically for MacLean to increase shooting speeds underground. The pump also allows operators to switch from spraying to traditional concrete laying for underground construction purposes, which is an added bonus. The SS5 has a new three-phase thickness monitoring technology for shotcrete, a blockage detection sensor to improve safety during shooting, and a synchronized auto-dosing system for the accelerator.

"We're also developing a new system for accelerator dosing right at the nozzle based on a new way of atomizing the accelerator into the shotcrete itself," said Lavallee. "That will prevent over-dosing and increase savings that are going to be passed on to the mine."

"We're going hard on a 'no-boots-on-the-ground' philosophy with this machine," he explained. "The operator will be able to perform all the shooting applications from the cab without having to exit it and go under potentially hazardous, loose ground."

The SS5 was developed in-house based on the MacLean team's discussions with contractors, miners and operators on what they would like to see, and technology that is key for the future movement of the shotcrete industry.

The MacLean test mine was key throughout the project. The company acquired the facility, which is just down the road from its Sudbury branch, in 2018. And it has proved a solid investment, particularly as COVID restrictions during 2020 hampered the team's travel plans.

"We put some investment in to modernize the mine and now our Advanced Vehicle Technology Team is based there," said Stuart Lister, MacLean's director of marketing and communications. "The mine also has a dedicated team. Having this underground

lab has really accelerated our R&D and training capabilities. Even through COVID, our R&D work never stopped.”

New Markets and Applications

What’s next? *E&MJ* asked the team.

“In the immediate term, we’re working to round off our BEV fleet for underground hard-rock applications,” van Koppen explained. “There are still a couple of units that aren’t electrified yet like rock breakers and water cannons.

“And then, we’ll be continuously improving and enhancing our designs, like we’re doing with the additional battery options. And there will be crossover between our automation, digitalization, and electric offerings that we’ll start focusing on as well.”

“In 2021, we’re looking to cast our net a little bit wider geographically, too,” Lister said. “We’ve got a great network across Canada and we want to take that into the U.S., Australia and Scandinavia as well.”

“Yes, and to take these vehicles international, we’ll be making minor adjustments to suit localization requirements,” Patrick Marshall, VP of Product Management at MacLean, joined the discussion. “For example, in Australia we will incorporate how sites want to see their e-stop circuits configured and ensure compatibility with local voltage standards.

“As we go into 2022, we’re looking at new applications too — because of the success of MacLean’s EV Series drive train, we’ve got an opportunity to bring to market battery vehicles that aren’t in our traditional diesel portfolio. We will also start to diversify into other streams of underground mining, low-profile mining, for example. Platinum and palladium mines in South Africa are very interested in electrification. I think that’s the next big customer base to support.”

Normet Expands SmartDrive With Fast Charging

Normet launched its SmartDrive, BEV product portfolio at the Bauma exhibition in Germany, April 2019. Since then, the company has added products for concrete transportation and spraying, explosives charging, lifting and installations, and underground logistics for both underground mining and tunneling.

“We have two different battery-electric architectures: a mining architecture optimized for long tramming distances, and a tunneling architecture optimized for needs

in tunneling applications,” Samu Kukkonen, technology director for Normet’s Equipment Business, said.

Normet has recently expanded both architectures to include fast-charging battery technology. This allows for rapid charging without major impact to the battery lifespan.

“Fast charging is a natural option for Normet machinery, and it means there is no need for battery swapping,” Kukkonen explained. “By choosing fast charging over battery swapping, we have eliminated the possibility to damage batteries during swapping, and we have designed the machine structure so that batteries are secured and covered to ensure safety.

“In addition to safety benefits, battery swapping is also much more tedious and expensive to implement. We believe that fast charging is the future, as it is for electric cars. And we are supporting the common CCS fast charging standard.”

Normet demonstrated battery-electric emulsion charging at Pyhäsalmi during 2019 and the technology is now commercially available.

“We already have multiple sites globally where SmartDrive’s are being operated,” Kukkonen said. “In addition to Pyhäsalmi, the first BEV for underground explosive charging on Australian soil was the Charmec MC 605 VE SmartDrive, which operates with Downer Blasting Services at OZ Mineral’s Carrapateena mine in South Australia.”

In all SmartDrive machines, safety and efficient performance have been the main drivers for development.

“Combining the most advanced process expertise with the latest BEV technology allows us to offer our customers products to meet today’s stringent requirements. In the field of sprayed concrete, for example, we have machines in Norway and Australia, and we were the first company to supply concrete sprayers with BEV technology with our Spraymec 8100 VD SD,” Kukkonen added.

“We believe that BEVs are the future for mining. There are many more benefits in using BEVs in the mining industry than in road vehicles.”

Sandvik: A New Loader, and More...?

At a virtual event in September, Sandvik presented its first 18 metric tonne battery loader, the LH518B. This model, which brings Sandvik’s battery electric LHD range to four models, combines the company’s expertise in vehicle engineering with Artisan Vehicle Systems’ powertrain and battery technology.

The LH518B was designed from the ground up around Artisan’s battery system and electric driveline. The design allows it to work in 4.5 x 4.5-meter tunnels and, in addition to a new boom and bucket system, the LH518B features independent front and rear drivetrains, allowing a high payload capacity while keeping the overall machine height low.

The loader is equipped with three 2000 Nm permanent magnet motors. With no torque converter, transmission or engine to rev up, Sandvik said the loader is fast and agile and there are no emis-



Epiroc’s ST14 battery-powered loader in action underground. (Photo: Epiroc)

sion restrictions based on installed power to limit the electric motor selection.

The LH518B is also equipped with Artisan's patented AutoSwap battery swapping system, which requires no lifting equipment or infrastructure. Changing the battery takes six minutes, and the new AutoConnect feature, which makes its debut on the LH518B, allows the machine to automatically connect and disconnect the battery pack. This means that, aside from plugging in and unplugging the charger, the operator doesn't need to leave the cabin.

The battery pack uses lithium-iron-phosphate chemistry (LiFePO₄) and is purpose-designed for use in underground mining.

In the LH518B press release, Sandvik hinted that it is working to expand its BEV loader and truck offering and preparing to enter new market areas.

E&MJ asked Katja Rivilä, marketing manager for load and haul technology at Sandvik, what's next?

"One of our guiding design principles is the matching pair thinking," she said. "Considering the payload capacities, you need to be able to load a truck with a loader in an efficient way. Coming from here, we are planning to introduce new trucks to match with the loaders. Of course, in the long run, we are building a comprehensive fleet of battery-electric loaders and trucks of different size classes."

The company is also working to minimize the potential impact of BEVs on mine infrastructure.

"Changing from traditional technology to BEVs needs to be easy and flexible for the mines," Rivilä said. "For this reason, we are focusing on a self-swapping system for batteries, eliminating the need for



Normet's battery electric Charmec MC 605 VE SD at Pyhäsalmi in Finland. (Photo: Normet)

lifting discharged batteries and swapping to a new one with an overhead crane; our equipment does that all by itself, controlled by the operator sitting in the cabin. Our patented auto-swap technology is also developed to minimize swapping time; changing the battery must be fast enough not to compromise productivity."

In 2021, Sandvik will be trialing several LH518B loaders at different mine sites to get customer feedback on the loader, plus actual performance data. The LH514BE is also in the pipeline. This is a battery-assisted loader that combines cable-electric and battery technologies; when the LH514BE is mucking, it draws power from an electrical cable, but when travelling, e.g., to a different mine section or to the workshop, the machine gets its power from the battery, and the cable can be unplugged from the mine network. Sandvik believes this combination will significantly increase the flexibility and ability to move the loader, compared to the cable-electric models.

"We believe BEVs is the right direction to take," Rivilä added.

"Diesel engines are not going to disappear overnight, and we are therefore putting significant efforts into that technology too. But, what else will there be? What kind of hybrid technologies will be born...? That is an intriguing question and definitely something that the whole industry is buzzing about. Sandvik is not the exception, but today it is too early to comment about possible future hybrid technologies."

Barrick, Sandvik Partner for BEVs

Speaking of new trucks... On November 19, Sandvik and Barrick announced a partnership agreement to trial BEVs for hard-rock underground mining.

Over a three-year period, Sandvik will deploy four Artisan Z50 BEV trucks into production at the Turquoise Ridge gold mine in Nevada, part of the Nevada Gold Mines joint venture.

In phase 1 trials, the Z50, which has a 55-ton payload capacity, achieved more than 1,400 hours of production with more than 1,400 loads. It reached 18 hours of operation per day. Speeds of over 10km/h (6 mph) were also observed on the ramp to the tip.

Together with the Barrick team, Sandvik's dedicated site personnel are assessing key performance indicators including the performance of the BEV technology in a production environment, mechanical availability, average lifecycle cost and overall production cost.

Barrick President and CEO Mark Bristow said, "This partnership with Sandvik is exciting and will give us first-hand experience in BEV technology in our own production environment. It is a significant step to furthering our BEV strategy across the group."



In 2021, Sandvik will be trialing several LH518B loaders at different mine sites to get customer feedback. (Photo: Sandvik)