

EXPERT ROUND TABLE EVENT

BATTERY ELECTRIC VEHICLE (BEV) ECONOMICS IN UNDERGROUND CONSTRUCTION

White paper



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HAGERBACH TEST GALLERY, SWITZERLAND

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EXECUTIVE SUMMARY

The recent introduction of battery electric vehicles (BEV) to the tunneling and mining industry, has demonstrated positive benefits in reducing carbon emissions through decreased fossil fuel use and significantly increasing operational safety. Additionally, BEVs offer the advantage of reduced whole-life equipment and project costs. As is typical with technological changes, despite these positive attributes, there are legitimate concerns associated with BEV underground equipment, such as the economic viability of high-capacity batteries, their operating range, and the required charging infrastructure.

The SubSpace Energy Hub invited knowledgeable key stakeholders from the industry for an Expert Round Table Event held in the Hagerbach Test Gallery (VSH) in Switzerland on April 24, 2024. The roundtable's objective was to delve deeper into the economic concerns, understand what financial analyses have been conducted so far, and explore the current measures implemented to ensure cost efficiency.

The goal is to address these BEV concerns and gain broader industry acceptance, thereby accelerating the integration of BEVs in underground construction projects so that the industry as a whole can benefit from healthier, safer, lower-carbon yet also more economic processes.

Following the roundtable event, the partners of the SubSpace EnergyHub will advance several initiatives to support the industry and regulators in the transition to more sustainable underground construction sites by adopting BEVs. These initiatives include developing state-of-the-art recommendations for safe operator use, addressing economic considerations and providing comprehensive training for the use of BEVs in tunnel environments.

THE MAIN CONCLUSIONS FROM THE MEETING CAN BE SUMMARISED AS FOLLOWS:

- 1. Total Cost of Ownership (TCO) over vehicle's lifetime:** The panel emphasized the importance of considering the total cost of ownership over the lifecycle of BEVs. While initial capital costs are higher, operational savings due to lower maintenance and energy costs are substantial.
- 2. Preference for Purchasing Equipment:** There is a general preference of contractors for purchasing equipment for specific projects. This approach allows for cost amortization over multiple uses, which can be more cost-effective in the long run compared to renting, considering a project-based approach, especially in tunneling.
- 3. Potential Shift to Renting Business Models:** Some panelists suggested that the future might see a shift towards renting machinery instead of purchasing it. This would reduce upfront costs and provide flexibility in upgrading to newer technologies.
- 4. Maintenance Cost Reductions:** It was emphasized the need for reducing maintenance costs by 30-50%, while acknowledging the complexities of managing energy as a confined asset under a battery-as-a-service model.
- 5. Importance of Legislative Drivers:** Regulations mandating zero-emission work sites are critical in driving the adoption of BEVs. Such regulatory frameworks compel companies to transition to cleaner technologies.
- 6. Safety and Environmental Benefits:** BEVs offer substantial safety and environmental advantages, including zero-site emissions and quieter operation. These benefits improve working conditions and reduce health risks for workers in underground environments.
- 7. Need for Governmental and Regulatory Support:** Clear governmental support and international regulation are essential to foster innovation and reduce risks in adopting high-tech machinery like BEVs.
- 8. Standardization of Charging Infrastructure:** Standardizing charging infrastructure was also suggested as an option to reduce costs and improve operational efficiency, making BEVs more economically viable and easier to integrate into existing operations.
- 9. Specialized Training and Skill Development:** It was highlighted the importance of comprehensive training programs to equip operators with the necessary skills to handle advanced BEV technology safely and effectively.
- 10. Strategic Transition Plans:** Phased implementation strategies, starting with (subsidized) pilot projects, are essential for a smooth and inclusive transition to BEVs. Addressing both technical and operational challenges is key to ensuring success.

These conclusions highlight the multifaceted considerations in adopting BEVs in underground construction, including economic, regulatory, operational, and training aspects. They underscore the need for a collaborative approach to fully realize the benefits of BEVs in enhancing sustainability and efficiency in the industry.

THE ROUND TABLE EVENT EXPERTS WERE AS FOLLOWS:



Felix Amberg
President
[Amberg Group](#) - Switzerland



Nathan Cables
New Business
Mining & Industrial
[Xerotech](#) - Ireland



Christoph Mueller
CEO
[Virturail](#) - Austria



Ross Dimmock
VP Tunnelling
[Normet Group](#) - UK



Uwe Stenner
Head of Mech. Eng.
[Implenia](#) - Germany



Remo Mueller
COO
[Motics](#) - Switzerland



Kim Massey
Zero Emissions Manager
[Rental Group](#) - Norway



Michael Kompatscher
General Manager
[Hagerbach Test Gallery](#) - Switzerland



Mark Ryan
VP Equipment Offering &
New Technology
[Normet Group](#) - Ireland



Daniel Owen
CEO
[Armstrong B2B](#) - UK



Marc-Andre Beck
CEO
[Grivix](#) - Switzerland



Gonzalo Ramirez Troxler
Corporate Innovation Director
[Codelco](#) - Chile

Roundtable Event: BEVs - Economics in Underground Construction (White paper)

Introduction

The roundtable event on Battery Electric Vehicles (BEVs) in underground construction brought together industry experts to discuss the economic benefits, current market trends, and the implications for sustainability and regulatory compliance. Participants included representatives from companies such as **Amberg Group, Hagerbach Test Gallery, Xerotech, Virturail, Implenia, Normet, Grivix, Codelco, Rental Group, Armstrong B2B**. This white paper summarizes the key conclusions drawn from the discussions, focusing on the economic viability, effectiveness, and future directions for BEVs in the underground construction sector.

TOPIC 1: REAL WORLD EXAMPLES OF STATE OF THE ART BEVs, USE OF IT AND MARKET TRENDS, STATUS AND IMPORTANCE OF SUSTAINABILITY, CO2 NEUTRALITY AND ESG.

MODERATOR – **DANIEL OWEN** – CEO – ARMSTRONG B2B

MARK RYAN (NORMET GROUP- VP EQUIPMENT OFFERING & NEW TECHNOLOGY – FINLAND)

NATHAN CABLES (XEROTECH – NEW BUSINESS MINING & INDUSTRIAL – IRELAND)

CHRISTOPH MUELLER (VIRTURAIL – CEO – AUSTRIA)

UWE STENNER (IMPLENIA- HEAD OF MECHANICAL ENGINEERING TUNNEL CONSTRUCTION-GERMANY)

MARC-ANDRE BECK (GRIVIX- FOUNDER & CEO- SWITZERLAND)

Capital and Operational Expenditures

One of the primary points of discussion was the economic benefits of BEVs, particularly in terms of capital expenditure (Capex) and operational expenditure (Opex). **Nathan Cables** from **Xerotech** highlighted that although the Capex for BEVs is significantly higher—up to three times that of diesel vehicles—this cost is often overshadowed by the long-term operational savings. BEVs offer reduced maintenance costs and higher availability due to fewer moving parts and cheaper electricity compared to diesel fuel.

However, **Christoph Mueller** from **Virturail** and **Uwe Stenner** from **Implenia** pointed out a significant challenge: the industry's current accounting practices do not consider the total cost of ownership (TCO) over the vehicle's lifetime. Instead, procurement decisions are often driven by initial Capex, with little regard for long-term savings. This presents a barrier to the wider adoption of BEVs.

Ownership versus Renting

The debate over owning versus renting BEVs also emerged. **Uwe Stenner** from **Implenia** argued for purchasing equipment, emphasizing that ownership allows companies to amortize costs over multiple projects. This approach enables them to manage their assets more effectively and potentially reuse equipment across different projects, thus spreading out Capex over a longer period and more projects.

In contrast, **Christoph Mueller** from **Virturail** suggested a future shift towards a contracting model, where machinery is rented as needed, reducing the upfront financial burden on companies. Renting provides flexibility, allowing companies to upgrade to newer technologies without significant investment. This model, however, has yet to gain widespread acceptance due to the perceived higher long-term costs of renting. There is a need for a careful evaluation of the cost-benefit dynamics between owning and renting, considering project durations, equipment lifecycle and technological advancements.

Standardization and Infrastructure

Another economic consideration discussed was the need for standardization in charging infrastructure. **Marc- Andre Beck** from **Grivix** noted the current lack of uniformity in electric charging stations, which complicates investments in BEVs. The absence of standardized charging infrastructure leads to increased costs and logistical complexities, as companies need to invest in multiple types of charging solutions.

Standardizing power electronics and connectors across the industry would reduce costs and improve efficiency, making BEVs more economically attractive. This standardization would facilitate easier deployment and scaling of BEVs across different sites and projects, driving down overall infrastructure costs.

ROUND TABLE EVENT REPORT AND NEXT STEPS



TOPIC 2: EFFECTIVENESS OF BEVS IN UNDERGROUND PROJECTS EXPRESSED IN TCO FIGURES IN COMPARISON TO COMBUSTION ENGINE VEHICLES

MODERATOR – **ROSS DIMMOCK** –VP TUNNELLING – NORMET GROUP – UK

RAMIREZ TROXLER GONZALO FELIPE (CODELCO-CORPORATE INNOVATION DIRECTOR- CHILE)

KIM MASSEY (RENTAL GROUP -ZERO EMISSIONS MANAGER- NORWAY)

MARK RYAN (NORMET GROUP- VP EQUIPMENT OFFERING & NEW TECHNOLOGY – FINLAND)

Maintenance and Lifecycle Costs

The discussion on the effectiveness of BEVs in underground projects, as expressed in Total Cost of Ownership (TCO) figures compared to combustion engine vehicles, highlighted significant potential for maintenance cost reductions. **Gonzalo Ramirez Troxler** from **Codelco** noted that maintenance costs should be reduced by 30-50%, although comprehensive evaluations are still pending. BEVs present a challenge in terms of asset management, particularly with the shift to a battery-as-a-service model, which complicates the valuation and servicing of batteries. Unlike diesel, which is straightforward to purchase and transport, managing energy as a confined asset introduces new complexities.

Legislative and Regulatory Drivers

The role of legislation in driving the adoption of BEVs was another critical point. **Kim Massey** from **Rental Group** pointed out that Norway has set forth legislation mandating zero-emissions on work sites by 2025, underscoring the nation's ambitious environmental goals. While small machines are already compliant, larger machinery requires further advancements. Rental Group is actively collaborating with manufacturers to explore options such as grid-connected excavators integrated with battery technology, expected to debut in the market later this year, to meet these stringent regulatory requirements effectively.

Mark Ryan from **Normet** and **Nathan Cables** from **Xerotech** reinforced this perspective, suggesting that impending regulations, such as carbon costs and battery passports, will compel companies to adopt BEVs sooner rather than later. Compliance with these regulations not only meets legal requirements but also aligns with broader corporate sustainability goals.

Legislation acts as a catalyst for change, pushing companies to transition to BEVs by creating a financial imperative. Penalties for non-compliance and incentives for adopting zero-emission technologies can significantly influence company strategies. Thus, proactive engagement with policymakers and regulatory bodies is crucial to ensure that the industry is well-prepared to meet these emerging standards.

Safety and Environmental Benefits

In addition to economic considerations, the roundtable highlighted the safety and environmental benefits of BEVs. Fire Risk during operations were discussed in an earlier Round Table and clear mitigation means are available. BEVs produce zero emissions at the point of use, significantly improving air quality in underground environments. This is particularly important in tunneling and mining operations, where ventilation costs and health risks associated with diesel exhaust can be substantial. By reducing harmful emissions, BEVs contribute to a healthier and safer working environment for personnel.

Moreover, the reduced noise levels of BEVs enhance the working conditions, making communication easier and improving overall safety. These benefits, while often secondary in economic calculations, provide compelling reasons for the adoption of BEVs, contributing to the overall sustainability and safety objectives of companies.

ROUND TABLE EVENT REPORT AND NEXT STEPS



TOPIC 3: DISCUSSION AND STEPS FORWARD: WHAT DO WE DO TO HAVE GOVERNMENTAL BODIES INVOLVED? DOES LACK OF INTERNATIONAL REGULATION IMPOSE A LOT OF RISK AND PREVENT INNOVATION?

MODERATOR – **FELIX AMBERG** – PRESIDENT – AMBERG GROUP – SWITZERLAND

ALL THE ABOVE, **REMO MÜELLER** (COO - MOTICS - SWITZERLAND), **DAVID PROESCHEL** (COO/FOUNDER – TERREN ELECTRIC DRIVE SYSTEMS - SWITZERLAND)

Governmental Involvement and International Regulation

A key theme was the need for greater involvement from governmental bodies and the establishment of international regulations to mitigate risks and foster innovation. **Christoph Mueller** from **Virturail** emphasized that the future of high-tech machinery in construction lies in contracting models and digitalization, supported by robust regulatory frameworks. While regulations are necessary, **Michael Kompatscher** from **Hagerbach Test Gallery** suggested that a fundamental change in attitude within the industry is crucial for widespread adoption.

Engagement with government agencies to advocate for supportive policies and incentives can drive the industry forward. International collaboration on regulatory standards can also facilitate the adoption of BEVs by providing clear guidelines and reducing market fragmentation. The establishment of global standards for BEV technology and infrastructure will help streamline the transition and encourage investment in sustainable practices.

Mark Ryan from **Normet Group** emphasized that with increased familiarity, operators demonstrate heightened problem-solving abilities, leading to a more positive work environment where daily challenges are overcome more effectively, enhancing overall job satisfaction and teamwork dynamics. This positive experience sets off a ripple effect, transforming routine tasks into more manageable and enjoyable activities, thereby fostering a better workplace atmosphere across the industry. At the same time, major mining companies are increasingly compelled to align with sustainability objectives, driven by the operational efficiencies and environmental benefits offered by electrification.

Marc-Andre Beck from **Grivix** underscored the challenges inherent in electrifying open-pit mines, particularly in terms of building new infrastructure such as DC-micro grids with extensive battery systems, which entails significant upfront costs and logistical complexities. Addressing these challenges, the SubSpace Energy Hub (SSEH) advocates for a comprehensive approach that integrates various technological aspects relevant to construction and mining environments. SSEH aims to support industry stakeholders in testing, adopting, and seamlessly integrating these technologies to meet site-specific requirements while advancing sustainability goals effectively.

Training and Skill Development

The discussion also touched on the need for specialized training and skill development to operate BEVs. As the technology becomes more advanced, the demand for skilled operators will increase. **Uwe Stenner** from **Implenia** noted that while current workshop personnel can handle most maintenance tasks, the transition to high-voltage battery vehicles requires specialized expertise, increasing operational costs if external suppliers are needed for training.

Christoph Mueller from **Virturail** noted that as equipment becomes more advanced, the need for skilled operators will grow, with each decision having a higher impact on project outcomes. Partnerships with educational institutions and training providers can facilitate this process, creating a pipeline of skilled professionals ready to support the industry's transition.

Transition Strategies

The outcome of the discussion underscored the imminent shift towards BEVs, with **Ross Dimmock** from **Normet Group** emphasizing the need to strategically address transitional challenges, whether the transition occurs in the near term or by 2030. **Nathan Cables** from **Xerotech** highlighted the importance of proactive planning ahead of forthcoming regulatory pressures and market dynamics, such as impending carbon pricing and EU-mandated battery passport requirements expected between 2027-2032, which will compel industry compliance. **Marc-Andre Beck** from **Grivix** stressed the urgency of establishing standardized practices to facilitate the broader adoption of BEVs, particularly in developing infrastructure that supports autonomous driving capabilities with unified connectors, contrasting with the standardized interfaces seen in diesel vehicles. **Christoph Mueller** from **Virturail** expressed confidence in resolving connector challenges within the specialized construction industry context by specifying appropriate connector types for mining operations, and they are not seen as the main obstacle in the discussion.

Financial and Market Implications

The financial implications of transitioning to BEVs extend beyond initial investments. The market for BEVs is expected to grow, driven by advancements in battery technology, increasing energy efficiency, and declining costs of renewable energy sources.

Companies should conduct thorough financial analyses to understand the full economic impact of adopting BEVs. This includes evaluating the return on investment (ROI), assessing potential risks, and identifying opportunities for cost savings. **Remo Mueller** from **Motics** claimed that there might be a “currency” problem and emphasized the importance of considering the right currency factors in tender processes. By aligning their financial strategies with market trends and regulatory requirements, companies can ensure a sustainable and profitable transition to BEVs.

Nathan Cables from **Xerotech** further emphasized that without financial incentives or penalties incentivizing change, the widespread integration of BEVs into industry practices may face delays. Overall, the panel emphasized the need for a strategic and collaborative approach among stakeholders to overcome barriers, establish clear standards, and foster a sustainable framework that supports the effective adoption of BEVs in underground and mining environments.

Conclusion

The roundtable event underscored the economic, operational, and regulatory factors influencing the adoption of BEVs in underground construction. While the higher initial Capex remains a barrier, the long-term Opex savings, driven by reduced maintenance and fuel costs, present a compelling case for BEVs. Standardization of charging infrastructure and regulatory support will be critical in driving this transition. Furthermore, investing in specialized training and adopting flexible business models will help the industry navigate the complexities of this technological shift. The path forward requires a collaborative effort between industry stakeholders, regulatory bodies, and technology providers to realize the full potential of BEVs in underground construction.

The industry must embrace a holistic approach, integrating economic, environmental, and social considerations to achieve sustainable development. By leveraging technological advancements and regulatory frameworks, the underground construction sector can lead the way in the global transition to cleaner, more efficient, and sustainable operations.