

Battery electric vehicles – following the current

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BEV – the global trend

- Deeper mines – heat issues
- More stringent regulations
 - Environmental concerns
 - Health and safety concerns
- Interest from the mining companies – testing and research projects
- Push from the equipment manufacturers – continuous development ongoing
- Long lead times, limited sizes, limited load/haul route lengths



BEV journey at LKAB

- First research project within Sustainable Underground Mining (SUM) program
 - Started in 2018
 - Co-operation with Epiroc, Sandvik, ABB, and Combitech
- Participation in SIMS (Sustainable Intelligent Mining Systems) program in 2019
- LKAB strategy, May 2021 → CO₂ free processes and production by 2045
- First test machines delivered by Epiroc to Kiruna, September 2021
 - One loader and two trucks
- First Sandvik truck delivery for testing in Malmberget, March 2023

Euro Mine Expo in June 2022, Skellefteå, Sweden



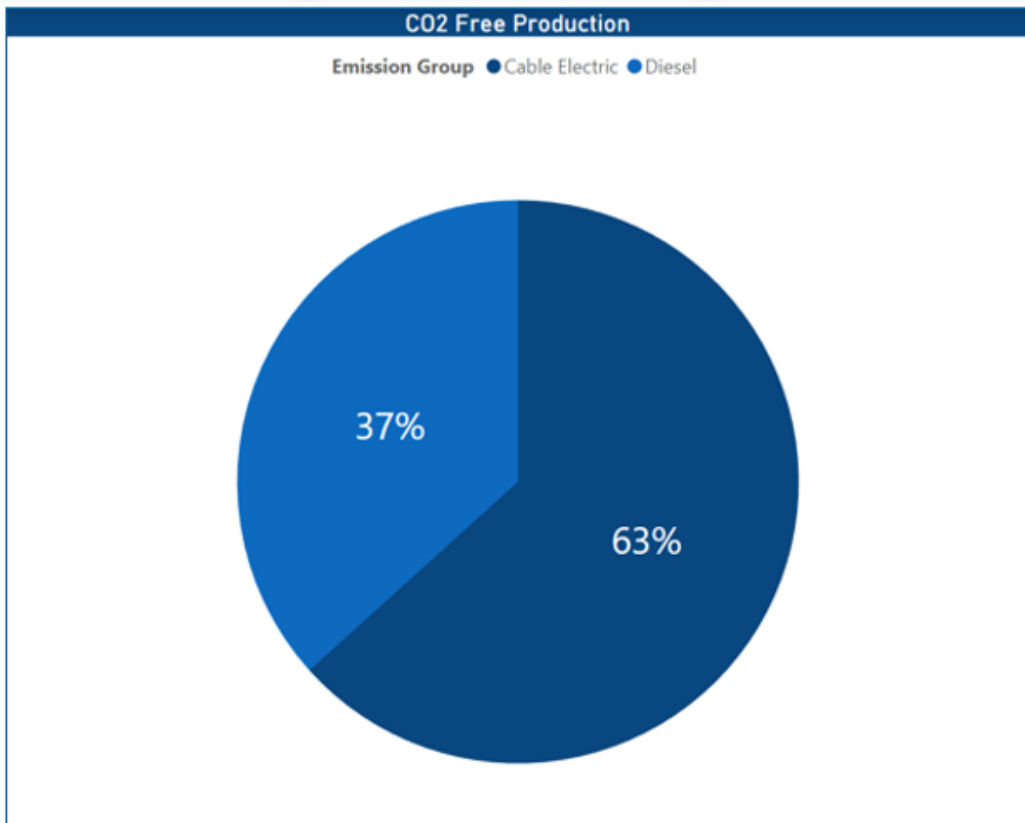
Malmberget mine, level 1250, June 2023



LKAB mines – conditions for BEV

- Relatively low temperature and humidity variations underground
- Currently, no heat issues
- Gas sensor installation requirements, placements
- Large temperature variations on the surface
- Potential heat issues in the future, with deeper mines
- Infrastructure requirements problematic
- Ventilation capacity reduction
 - Radon?

Roadmap towards an all-electric fleet, Kiruna



Moving forward in Malmberget

- GHH: Testing of a 19-ton electric loader, delivery planned for late 2023
 - Scania: Two trucks for Malmberget, late 2023
 - Service truck, underground
 - Surface ore transport truck
 - Goal to have five LHD's and three trucks fully operational before 2026
- A nearly 30% reduction of total CO₂ emissions on site by 2026

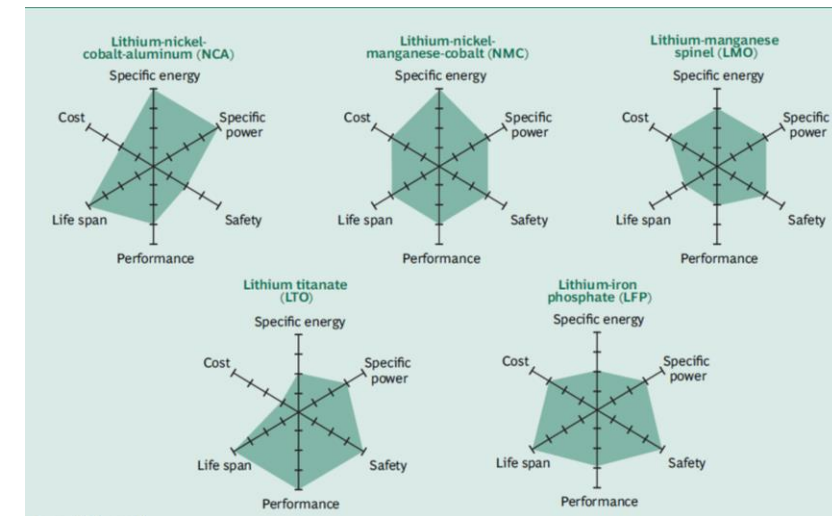


Environmental aspects – global view

- Several battery technology options exist, but all use lithium
 - Much of the energy used to extract and process it comes from CO₂-emitting fossil fuels
 - For every ton of mined lithium, approximately 15 tons of CO₂ are emitted into the air
 - Battery manufacturing industry adds to CO₂ emissions
- Even so, emissions are lower than those deriving from fossil fuels production

→ Right direction, but far from CO₂ free

- Currently, batteries are not designed to be recycled
 - Available processes produce waste and emit greenhouse gases
 - Only about 5% are recycled



Environmental aspects – local view

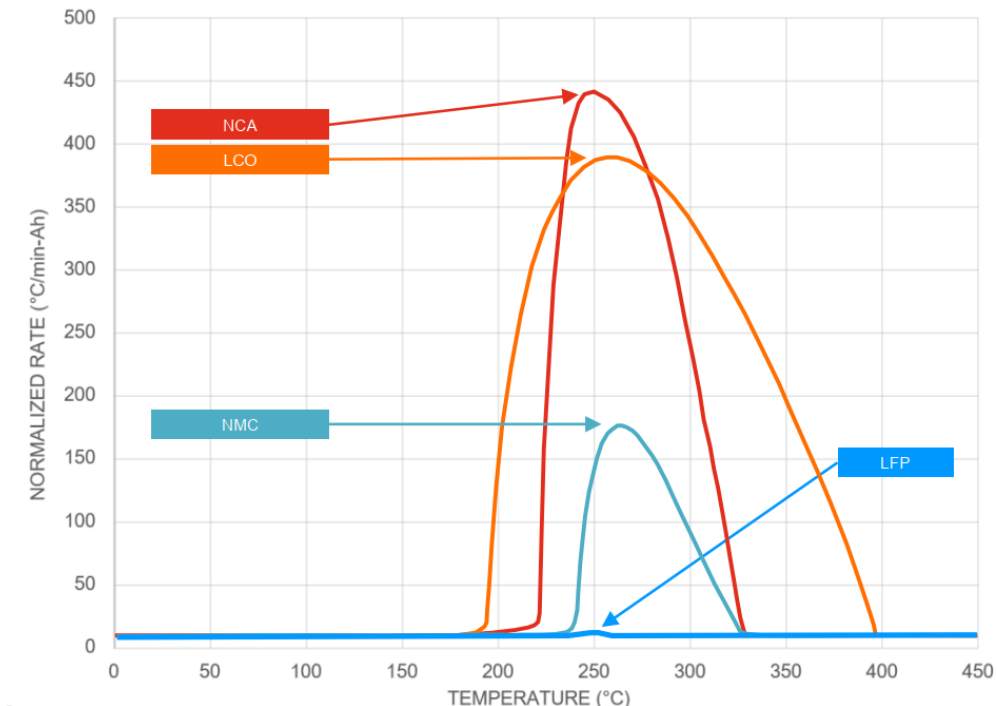
- No release of CO, CO₂, NO_x, and DPM like from diesel vehicles to be exhausted out of the mine during use
- Potential for decreased ventilation capacity – decreased use of energy
 - Energy savings may result in reduced CO₂ emissions
 - Decreased heating requirements as well – further reduction in CO₂ possible
- Battery disposal and waste management issues
 - Battery service cost including the “second life of battery” is approximately half of the total cost for BEV



Health and safety considerations – global view

- Fire safety
 - Constantly improved safety features
 - Small-scale and large-scale testing results available
 - Examples concerning risks and fire events from industry
- Health
 - Universally recognized for health benefits
 - No diesel exhaust gases, no DPM
 - Decreased heat output
 - Decreased noise levels
- Ventilation for BEV – guidelines

HEAT RELEASED IN A THERMAL RUNAWAY



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SOURCE: "New developments in battery safety for large-scale systems", Lamb et al. (2021)

Health and safety considerations – local view

- Fire safety
 - Fire tests – Epiroc battery cells
 - LKAB fire department risk assessments
 - Risk evaluations in co-operation with Sandvik, Epiroc, and Scania
 - Fire suppression and other fire safety system evaluations
 - Upgraded operator and rescue team equipment
- Health
 - Compliance with new regulations
 - Less health-related gas surveys expected
 - New continuous monitoring systems



Zooming out – the bigger picture

Gold Fields to trial Sandvik battery loader and truck at St Ives operation's high grade Hamlet North mine

New Gold's New Afton copper-gold mine grows Sandvik BEV fleet

Sandvik to deliver 'biggest BEV fleet to date' for Foran's McIlvenna Bay

Rio Tinto funds initial underground development at Kennecott copper ops

Torex Gold selects 35-strong Sandvik fleet including 11 auto-ready BEV LHDs

Sandvik to supply Rana Gruber with 19-strong fleet of battery-electric vehicles

Newcrest's Brucejack Gold Mine Advances Towards Decarbonization

BEV fleet heads for one of India's largest zinc mines

Zooming out – our options

- Alternatives
 - Hydrogen vehicles – Development and research projects ongoing, no equipment available for underground mining yet
 - Liquid air vehicles – Dearman engine technology; company has ceased to exist
 - Cable tethered electric vehicles – The other electric option, which we already have in place on our sites where applicable
 - CO₂ free by 2045
- There are no options – we are left to follow the current

Thank you!

Questions?

Picture from the Atlantic; Knud Pfeifer / Picture Press / Redux