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Battery Fleet Management Achieving Daily Production

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WSN Battery Electric Symposium



Mayhew Performance

- Founded in 2020 (Mike/Nicole Mayhew)
- 50 Years Combined Experience in Mining and Health Care
- 4 Pillars to Mayhew Performance
 - Innovation & Technology
 - Operational Excellence
 - Health & Safety, Health Care Nursing
 - Business Development & Marketing

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Kirkland Lake Gold Macassa Mine



Quick Facts

| | |
|----------------------------|---|
| Location | Town of Kirkland Lake, 580 km north of Toronto, Ontario |
| Mine Type | Underground, shaft access |
| 2019 Production | 241,297 ounces |
| Deposit Type | Orogenic greenstone hosted gold (Lode Gold deposit) |
| Process | Carbon in Pulp (CIP) |
| End Product | Gold doré |
| Infrastructure | #3 Shaft, 2,200 tpd capacity Macassa Mill (ore and waste) |
| Commenced Operation | 2002 by Kirkland Lake Gold, producing since 1933. |





Advantages for Battery Equipment

Air Quality
The machines have no emissions. Fleet consists of loaders and trucks as they offset the most emissions per kW of fleet power, resulting in cleaner air.

Dust
No exhaust to blow particulates and fugitive dust into the air.

Heat
Less heat generation during mucking cycle temperature increase of under 2 C versus 8 C

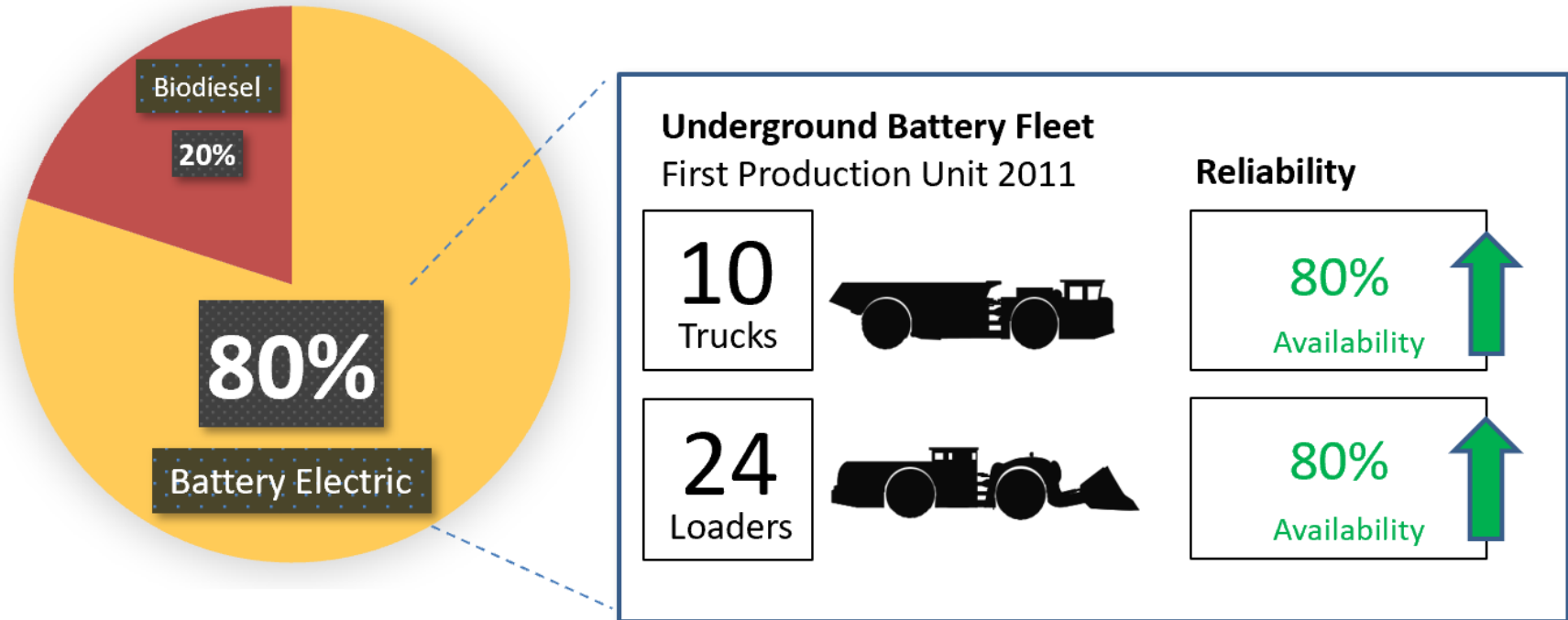
Ergonomics
Less heat, vibration and noise, operators are less tired at the end of the shift.





Fleet Management and Performance

Production at KLGold Macassa



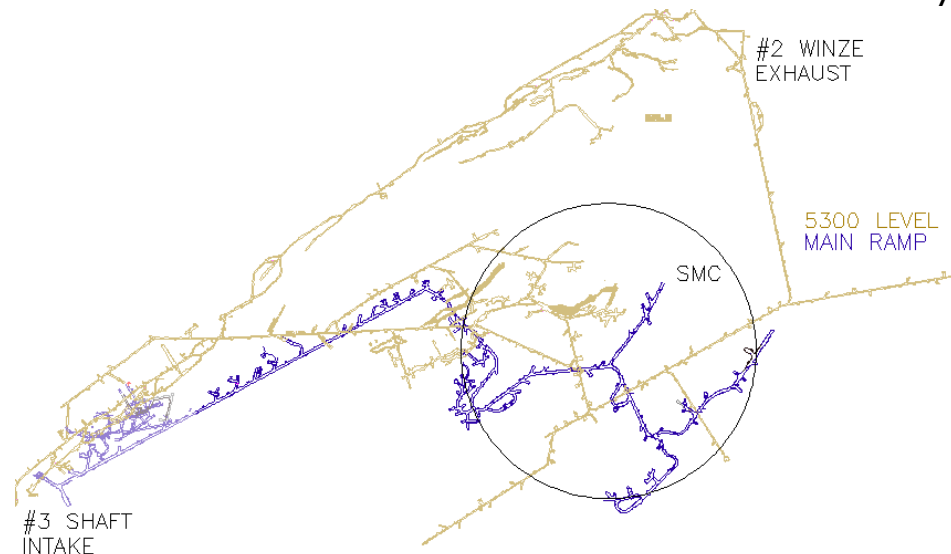
Similar performance compared to diesel equipment.





Why Battery Technology At Macassa

- SMC (South Mine Complex) below 5000 ft depth is connected to old Macassa infrastructure
- Limited airflow is available through the old workings to surface and therefore through the mine. The new Shaft4 will help with ventilation in the years to come.
- Not enough airflow through the mine for the equivalent diesel equipment.
- Battery affords increased mobility relative to diesel equipment as the mine gets deeper.
- Haulage is in fresh air and could not be done exclusively with diesel trucks due to contaminants





Case Study Z40 / MT2010

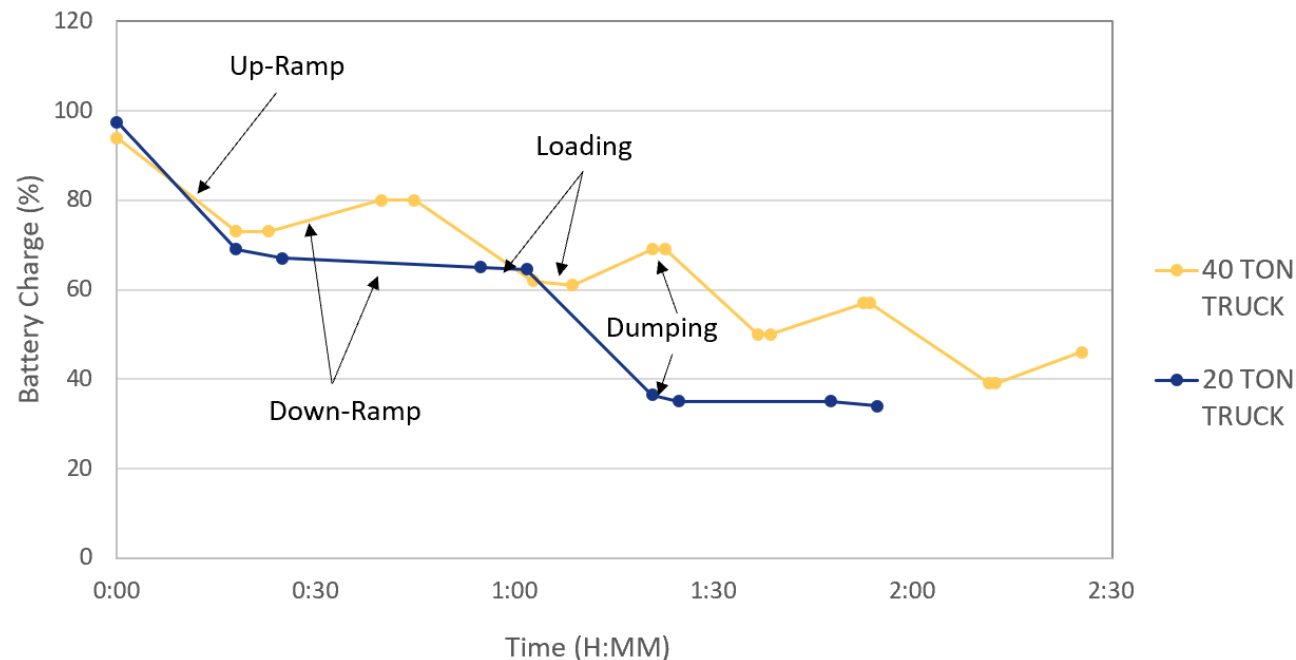




Case Study Z40 / MT2010

Haul Truck

- Time Study was done to gather battery use data from various battery trucks.
- Trucks haul up-ramp loaded and down-ramp empty.
- 40-ton trucks equipped with regenerative braking.
- The regenerative braking results in less power consumption, less heat generation, and less battery changes.





Case Study Z40 / MT2010

Haul Truck

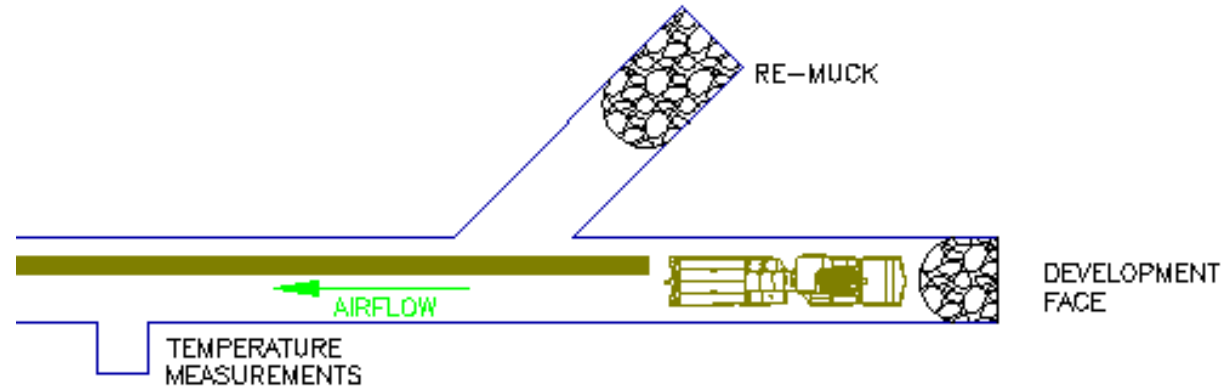
- Energy Use of Equipment = Potential Energy + Energy Converted to Heat
- Potential Energy calculated based on mass and elevation difference
- Resultant Energy & Power calculated

| | Z-40 | | MT-2010 | |
|-----------------------|-----------------|--------------|-----------------|--------------|
| | Energy | Avg. Power | Energy | Avg. Power |
| Up-Ramp Time | 16 min | | 18 min | |
| Battery Use | 66.3 kWh | 249 kW | 40.8 kWh | 136 kW |
| Potential | 45.9 kWh | 172 kW | 24.1 kWh | 80.3 kW |
| Resultant Heat | 20.4 kWh | 77 kW | 16.6 kWh | 55 kW |
| Down-Ramp Time | 14 min | | 32 min | |
| Battery Use | -24.9 kWh | -107 kW | -2.3 kWh | -4 kW |
| Potential | -27.7 kWh | -119 kW | -14.9 kWh | -28 kW |
| Resultant Heat | 2.7 kWh | 12 kW | 13.7 kWh | 25 kW |





Case Study Loaders



- Testing done to compare the temperature increase while mucking with a battery scoop versus with a diesel scoop
- Wide variability in temperature from one test to another in both battery and diesel
- Performance and power a major difference Battery vs Diesel.

| | Temperature Increase (°C) | Water Content Change (g/kg) | Enthalpy Increase (kW) |
|----------------------|---------------------------|-----------------------------|------------------------|
| Battery Scoop | 0.8 | 0.0 | 7.3 |
| Diesel Scoop | 4.5 | 1.6 | 53.7 |





Lesson Learned in Operations

Safety and Maintainability

Design electrical systems with arc flash safety in mind.

- Typical electrical worker PPE (coveralls, hard hat, boots, gloves, face shield, etc.) provides protection up to 8 cal/cm².
- Incident energy over 8 cal/cm² typically results in workers wearing face shield with hoods, jackets, etc. which make performing tasks challenging.
- If equipment design does not consider the arc flash hazard, it may be very challenging to operate, or repair.



Standard Arc Flash Design Principles Apply:

1. Lock out procedure.
2. Covers and barriers.
3. Physical separation.
4. Overcurrent protection.
5. Break system up into smaller and safer segments.
6. Avoid live work.





Challenges with Battery Technology

While battery electric equipment offers significant benefits to an operation, the benefits are not without corresponding to the operating costs and challenges:

Capital Cost

Machines are more expensive to purchase and require investment as it relates to training and maintenance.

Limited Product Range

Machines are available in limited size classes from a limited number of manufacturers. However, that is growing and we are seeing growth of new product.

Operating Cost

Battery cells require replacement (contributing to higher operating costs), components are relatively expensive and have less design history to ensure reliability.





Market Outlook

Increased Market Competition

OEMs (Epiroc, Caterpillar, Sandvik, Komatsu, Kovatera, MacLean and others) have started to develop battery equipment for underground mining applications. The increased competition will drive improvements and innovation. Battery Suppliers; Artisan, FVT Research, Stack Tronic.

Mining Equipment will Benefit from the Automotive Industry

The Automotive EV market is growing rapidly and major OEMs are expanding their product offerings. This is expected to improve cost, reliability and choice of sub-components such as motors, inverters, controllers, battery chemistry.

Increased Performance

With increased product competition, all key machine performance measures (safety, power, energy, reliability, cost, etc.) will move in positive directions.

OEMs Gaining Experience and Moving to Increase Service Options

With the increased interest and adoption of EVs in mining, service companies are expected to be able to provide more complete service (repair, troubleshooting, parts, etc.)





Next Steps

Benchmarking

Working closely with industry such as OEMs, Battery Suppliers and Operations including mining consortiums such as the GMG, CIM, Colleges and Universities.

Increased Performance

With increased product competition, all key machine performance measures (safety, power, energy, reliability, cost, etc.) will move in positive directions.

Battery Management Systems & Integration

The Automotive EV market is growing rapidly and major OEMs are expanding their product offerings. This is expected to improve cost, reliability and choice of sub-components such as motors, inverters, controllers, battery chemistry.

Maintenance Planning & Training

Work closely with Operations, Maintenance and Training departments to ensure the BEV.

OEMs Gaining Experience and Moving to Increase Service Options

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Questions?



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Thank You