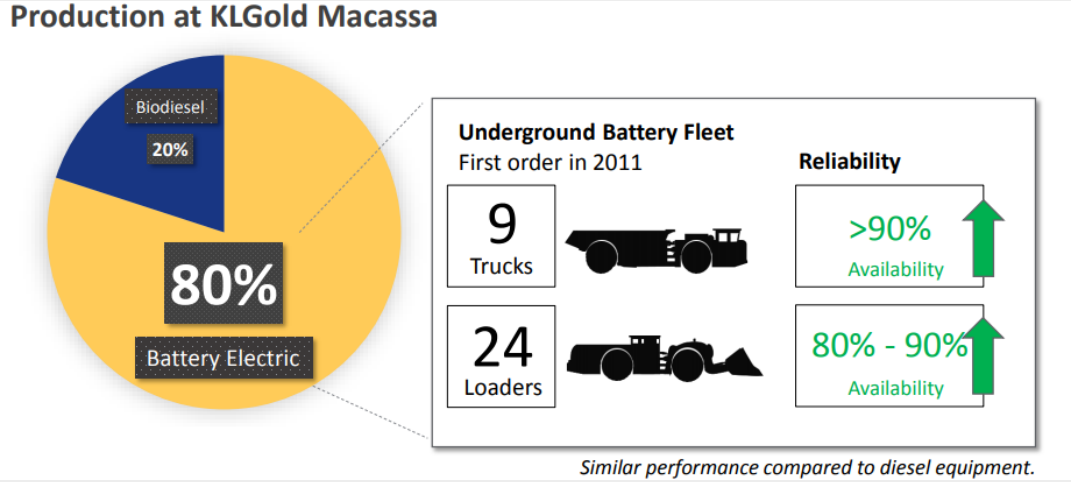
CONTENT	DETAILS	NOTES FOR COMPLETING THE TABLE
Company Overview	Kirkland Lake Gold	Give us a bit of background on your organization.
Project Name	Battery Technology at Macassa Mine and Shaft 4 Integration	Provide a short descriptive title that reflects the example and will capture the readers interest
ICSV Workstream	DPM	Indicate which ICSV workstream the project belongs too (VI, DPM, GHG)
Keywords	Battery, Electric Mine, DPM.	Please provide 4-6 keywords to help make the case study searchable.
Background	The Macassa Mine, located in the Town of Kirkland Lake, Ontario remains one of the highest gold grade mines in the world. Macassa commenced operations in 2002, and with the discovery of the South Mine Complex (SMC), has been able to increase its level of production significantly over the past five years. The SMC has been driving grade improvement at Macassa, with results from ongoing exploration drilling continuing to extend the SMC mineralization and adding to the Mine's Mineral Resources in support of growing production and extending mine life. The mine is located in an area with well-developed infrastructure, including a provincial highway, a railway system and a private airport. High-grade ore is processed at the Macassa Mill, which currently has available capacity and is located in close proximity to the mine.	Provide a short, focussed summary that considers the following: i. What was the issue or starting point? ii. What did you want to achieve? iii. How was this supported?
The Problem	• New Mine (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	Set the scene with background information and relevant facts. Be sure to: iv. Introduce the problem.

	• Not enough airflow through the mine for the equivalent diesel equipment. • Haulage is in fresh air and could not be done exclusively with diesel trucks due to contaminants	v. Explain why the problem is important and how it was identified. vi. Outline any assumptions (if any).
Steps Taken	Battery affords increased mobility relative to tethered electric equipment Kirkland Lake Gold is now carrying out more than 80% of its ore production from the Macassa gold mine in Ontario, Canada, with battery-electric machines. The company placed its first battery-electric machine order in 2011, but now has 24 battery-powered LHDs and nine haul trucks (including four 40 t Artisan Vehicles Z40 machines, and Epiroc and RDH Scharf LHDs, among other machines) 	Summarise what was done (activities/ interventions/inputs), where, by whom, for whom?

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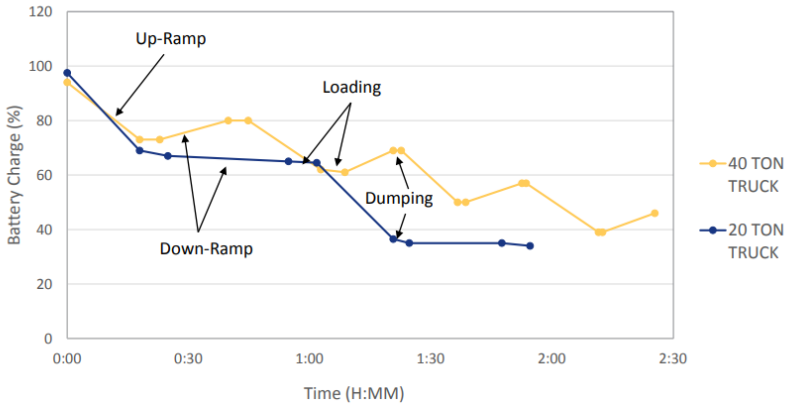
Results		What were the results of the intervention, focusing particularly the significant or unique results?

Time Study was done to gather battery use data from various battery trucks

Trucks haul up-ramp loaded and down-ramp empty

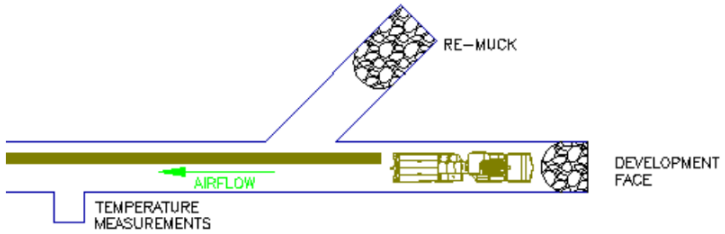
40-ton trucks equipped with regenerative braking

The regenerative braking results in less power consumption, less heat generation, and less battery changes



- 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



- Testing done to compare the temperature increase while mucking with a battery scoop versus with a diesel scoop
- Does not consider the effects of absorption & release of energy into strata
- Wide variability in temperature from one test to another in both battery and 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

Challenges & How they were met.

While battery electric vehicles offer significant benefits to an operation, the benefits are not without corresponding costs and challenges:

Capital Cost
Machines are more expensive to purchase.

Limited Product Range
Machines are available in limited size classes from a limited number of manufacturers.

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

Limited Technical Knowledge
Technology is new and limited support network (vendors, technicians, etc.). There is no network of service companies to provide expertise and labor to support varying business needs.

Focus on what challenges or difficulties were encountered and what you did to overcome them.

	Machine Design Challenges Machines have had mechanical issues due to new designs and additional weight on diesel designs. **Rapidly Developing Technology** Improvements and developments drive new opportunity but result in limited compatibility and interchangeability of spares. New units and designs have been replacing existing products resulting in several varieties of similar parts increasing the maintenance costs. **Training and After Sales Support** Most of the equipment has been the first generation so manuals, training, part lists, etc. are often not available which makes it difficult to develop maintenance programs.	
Beyond Results	**Currently Benefits Outweigh Costs** Currently the value to Macassa via the elimination of emissions and reduction of heat outweighs the additional costs and challenges associated with the battery equipment. **Ventilation Requirements as We Go Deeper** Heat loads will continue to increase as mining shifts deeper, and battery equipment will continue to be advantageous. **Future Favors Battery Equipment** We expect that in the future the balance of value to cost will continue to tilt in favour of battery electric vehicles.	Are the results mentioned above sustainable? Why or why not?
Lessons Learned	**Increased Market Competition** OEMs (Artisan, Epiroc, Caterpillar, Sandvik, Industrial Fabrication, MacLean, Marcotte and others) have started to develop and market battery vehicles for underground mining applications. The increased competition will drive improvements and innovation. **Mining Equipment will Benefit from On Road Electric Vehicles** The onroad EV market is growing rapidly and major OEMs are expanding their product offerings. This is expected to improve the cost, reliability and choice of sub-components such as motors, inverters, controllers, battery chemistry, etc. **OEMs Gaining Experience and Moving to Increase Service Options**	What lessons were learned: programmatic, technical, financial, process, etc?

	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.) **Increased Market Adoption** With increased product options and competition, all key machine performance measures (safety, power, energy, reliability, cost, etc.) will move in positive directions making battery electric vehicles a strong competitor to diesel vehicles across a wider range of applications.	
Further Information	N/A	Please provide us with details of any useful weblinks, links to video, references in CSR reports, news articles or research papers. .