Life of Mine Emissions Estimate

For Magna Mining's Shakespeare Mine

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Introduction

This report describes the Greenhouse Gas (GHG) emissions modelling activities that were undertaken by Synergy Enterprises and presents the projected life-of-mine (LOM) emissions profile of the proposed Shakespeare project. It also summarizes key opportunities for further emissions reductions.

Emissions were modelled in alignment with the principles and methodology outlined in the Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard[1]. Unless otherwise stated, emissions values are given in tonnes of carbon dioxide equivalent (tCO_2e).

Emissions from Pre-Production & Production

Boundaries

For the purposes of this analysis, three emissions models were created: a company level, a site level and a product level. The boundaries of these models are described in Table 1.

The company level model estimates Magna Mining's emissions in line with the GHG Protocol's Corporate Accounting Standard, and includes all material Scope 1, 2 and 3 emissions within the company's operational control.

The site level model estimates emissions from the Shakespeare site in particular, and includes only Scope 1 and 2 emissions.

The product level model estimates emissions to the first saleable product ("cradle to gate"), and includes all Scope 1 and 2 emissions, as well as Scope 3 emissions directly related to the transport and processing of the salable product. These boundaries are summarized in the table below.

[1] https://ghgprotocol.org/corporate-standard

Table 1. Pre-Production & Production Emissions Model Boundaries

		Company Level	Site Level	Product Level
Temporal Boundary		One year of pre-production and eight years of mining, based on the proposed LOM for the Shakespeare project.	One year of pre-production and eight years of mining, based on the proposed LOM for the Shakespeare project.	One year of pre-production and eight years of mining, based on the proposed LOM for the Shakespeare project.
Geographic Boundary		The Shakespeare project site, a 180 km^2 land package 10 km north-northwest of Espanola, ON and 70 km southwest of Sudbury, ON.	The Shakespeare project site, a 180 km^2 land package 10 km north-northwest of Espanola, ON and 70 km southwest of Sudbury, ON.	The Shakespeare project site as well as smelters in Rouyn-Noranda, QC and Sudbury, ON.
Organizational Boundary		All Scope 1, 2 and relevant company-level Scope 3 emissions	All site-level Scope 1 and 2 emissions.	All Scope 1, 2 and relevant product-level Scope 3 emissions.
Emission Sources (Operational Boundary)	Scope 1 (Direct Emissions):	• Diesel for vehicles & equipment • Propane for heating • Explosives	• Diesel for vehicles & equipment • Propane for heating • Explosives	• Diesel for vehicles & equipment • Propane for heating • Explosives
	Scope 2 (Indirect Emissions from Purchased Electricity, Heat or Steam):	• Electricity from HydroOne	• Electricity from HydroOne	• Electricity from HydroOne
	Scope 3 (Indirect Emissions from Other Sources):	• Upstream Shipping (e.g. fuel, mill balls) • Downstream Shipping (e.g. ore to smelters) • Staff Commuting		• Downstream Shipping (e.g. ore to smelters) • Smelting
	Biogenic Emissions	• Biodiesel	• Biodiesel	• Biodiesel
Excluded Emission Sources		• Business Travel • G&A emissions from Sudbury office		

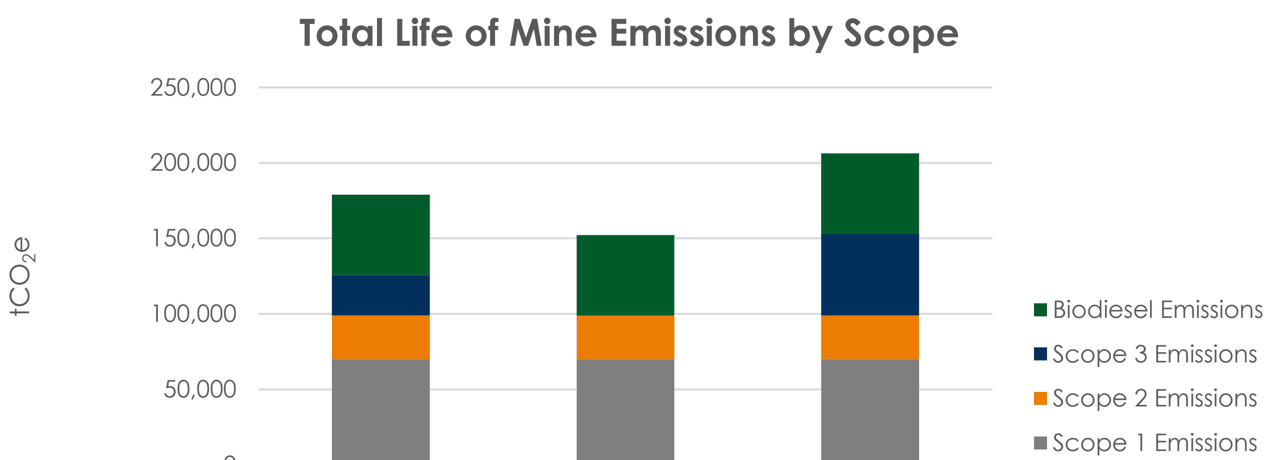
Total Emissions over Life of Mine

Total emissions are projected to be 178,972 tCO_2e at the company level, 98,904 tCO_2e at the site level, and 206,389 tCO_2e at the product level. Total emissions are summarized and broken down by scope in Figure 2.

In each model, 53,287 tCO_2e come from biodiesel due to Magna's use of a B50 blend for all vehicles and equipment. Using biodiesel reduces lifecycle emissions because the carbon dioxide released when the fuel is combusted is offset by the carbon dioxide absorbed from growing the feedstocks used to produce the fuel. For this reason, emissions from biodiesel are reported separately from emissions from fossil sources, and do not need to be offset should Magna choose to remain carbon neutral.

Scope 2 emissions have been reported using the location-based Ontario grid emissions factor. Moving forward, Magna intends to finalize an agreement with HydroOne to provide a power line directly from a nearby dam to the Shakespeare site. When this agreement is in place, Scope 2 emissions will be reporting using the market-based method, and will be reduced to zero.

Figure 1: Total Life of Mine Emissions by Scope



	Total Company-Level Emissions	Total Site-Level Emissions	Total Product-Level Emissions
Biodiesel Emissions	53,287	53,287	53,287
Scope 3 Emissions	26,782	0	54,199
Scope 2 Emissions	28,904	28,904	28,904
Scope 1 Emissions	69,999	69,999	69,999

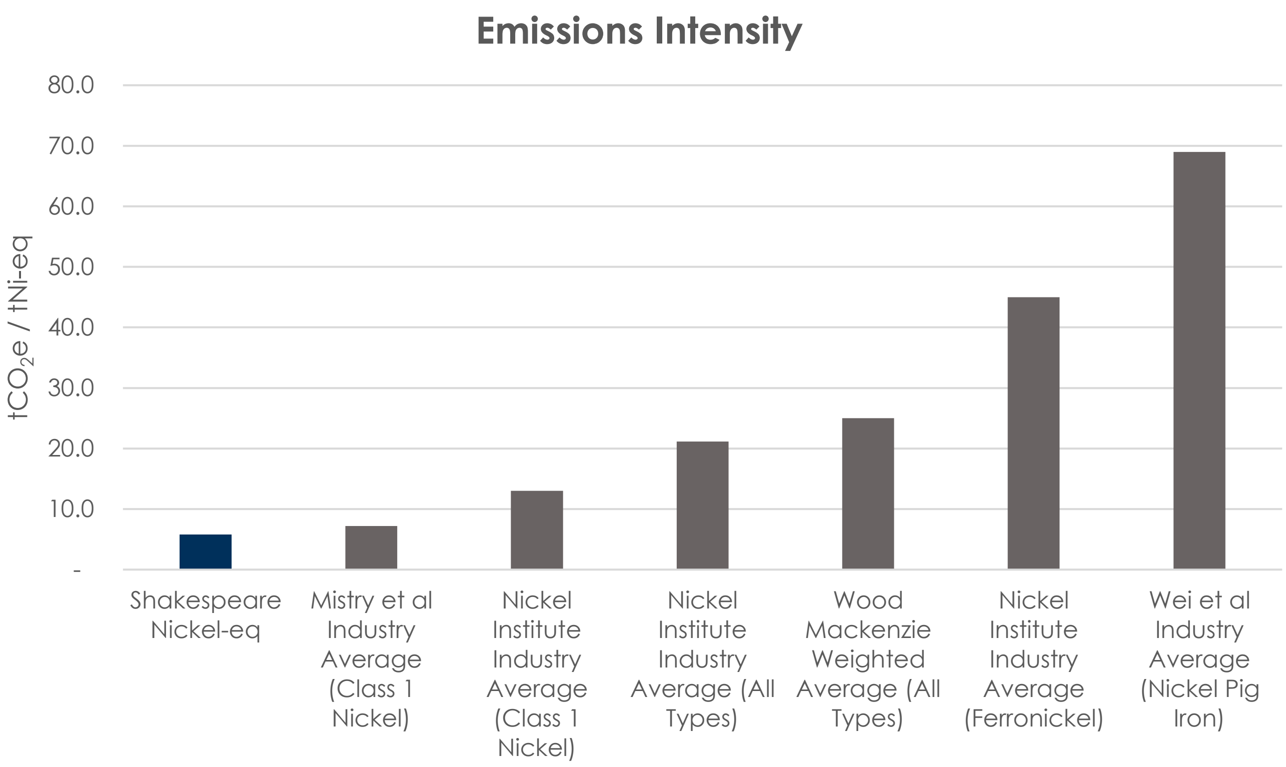
Emissions Intensity

The emissions intensity (tCO_2e/t Ore) of Shakespeare's nickel are given in Figure 2. These values were calculated using the product level model, to allow for meaningful comparisons to industry averages. Shakespeare's emissions intensity is below industry averages published by the Nickel

Institute[2], representing 52% of the global production of Class 1 nickel, and it is well below industry averages for all other types of nickel, particularly ferronickel and nickel pig iron.

One of the main reasons for the variation in emissions intensities is the type of deposit; sulphide ore deposits, which represent 40% of the world's identified nickel resources, tend to be high purity and require extraction processes that are comparatively less energy-intensive than laterite ores. Further, the increasing demand for nickel is driving the development of laterite deposits in countries like Indonesia and China, where energy grids are GHG-intensive. The Shakespeare deposit can achieve an emissions intensity well below averages because it is a sulphide deposit with access to clean power.

Figure 2: Emissions Intensity of Shakespeare Nickel-eq compared to industry averages[3]



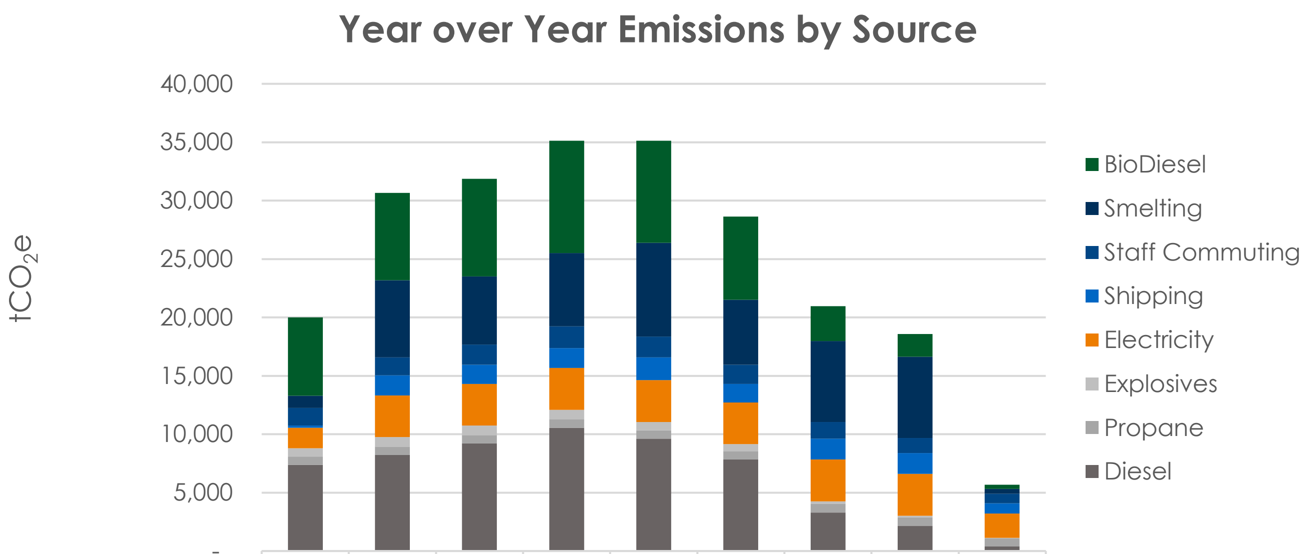
[2] Nickel Institute Lifecycle Data Executive Summary, June 2020. Note the Nickel Institute uses the following mass-based functional units: Class 1 Nickel = 1 kg of Class 1 nickel (>99.8%); Ferronickel = 1 kg nickel in ferronickel (with a reference flow of 3.7 kg ferronickel based on 27% nickel content); Nickel Sulphate = 1 kg of nickel sulphate hexahydrate (22% nickel content).

[3] "Life Cycle Assessment of Nickel Products" (Mistry et al., 2016); "Life Cycle Data" (Nickel Institute, 2020); "Energy Consumption and Greenhouse Gas Emissions of Nickel Products" (Wei et al., 2020)

Emissions Profile by Source

Diesel and biodiesel consumption are the largest emission sources at the Shakespeare site, at 26% and 24% of the total respectively (see Figure 3). Diesel emissions are followed closely by smelting, at 21% of the total. Emissions from electricity are the third largest emission source, at 13% of the total. All other emission sources account for less than 10% of the total.

Figure 3: Year over Year Emissions by Source



	Pre-Prod	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
BioDiesel	6,694	7,467	8,358	9,598	8,737	7,113	3,001	1,960	359
Smelting	1,044	6,616	5,834	6,291	8,035	5,561	6,924	6,953	408
Staff Commuting	1,506	1,538	1,724	1,870	1,781	1,643	1,417	1,287	818
Shipping	195	1,711	1,634	1,681	1,941	1,581	1,785	1,788	881
Electricity	1,748	3,581	3,581	3,581	3,581	3,581	3,581	3,581	2,088
Explosives	726	809	816	816	723	601	238	145	16
Propane	719	719	719	719	719	719	719	719	719
Diesel	7,366	8,218	9,199	10,564	9,616	7,828	3,300	2,155	391

Diesel

Diesel is used for excavation, haulage, and auxiliary services equipment, as well as for support service equipment such as shuttle busses, water and refueling trucks, and light vehicles. Emissions from diesel are calculated based on the total volume of fuel consumed.

Propane

Propane is used for heating in the mine concentrator, the truck shop, the effluent treatment plant and the admin and lab. Emissions from propane are calculated based on the total volume of fuel consumed.

Explosives

Emissions from ammonium nitrate/fuel oil (ANFO) explosives are calculated based on an explosives per tonne of material mined ratio.

Electricity

Electricity is primarily used in the processing plant, as well as for auxiliary infrastructure. Emissions from electricity for milling was calculated based on a kWh/tonne of milled material ratio, while emissions from electricity for auxiliary equipment was based on estimated annual consumption.

Shipping

Inbound shipments include fuel to site and mills balls for the processing plant. Outbound shipments include copper and nickel ore shipped to the Horne Smelter and Vale Smelter. Shipping emissions were calculated based on the estimated weights of all shipments, and the distance traveled.

Staff Commuting

Emissions from staff commuting were modeled for processing labour, general and administrative, and mine staff. Staff were assumed to be located in Sudbury.

Smelting

Emissions from smelting were modeled for copper ore processed at a smelter in Rouyn-Noranda, QC and nickel ore processed at a smelter in Sudbury, ON. Emissions were estimated based on the total Scope 1 and 2 emissions reported by each facility, weighted per tonne of ore processed.

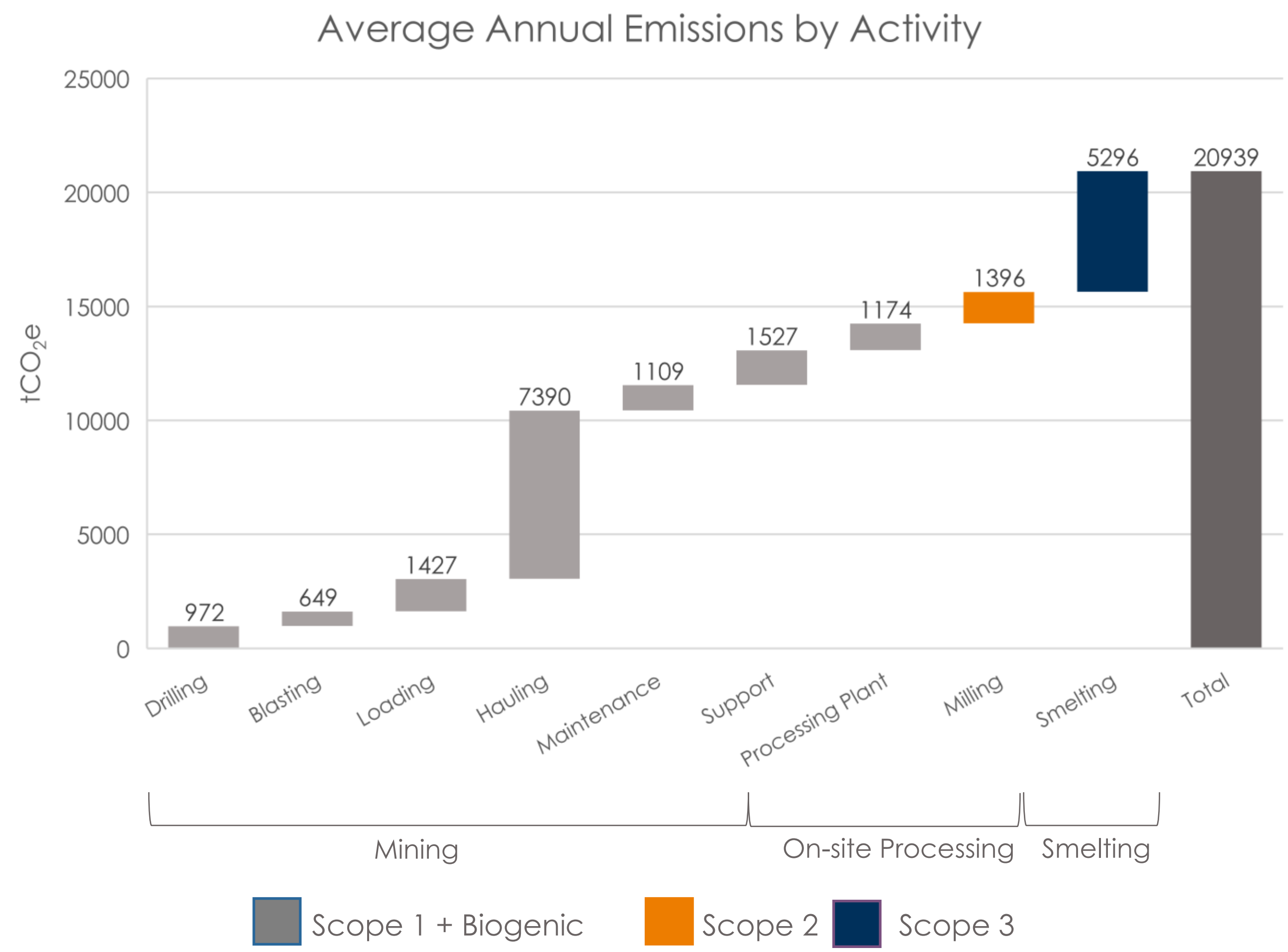
Biodiesel

The use of a B50 diesel blend results in emissions from biodiesel. Biodiesel emissions were calculated based on the total volume of fuel consumed. Because biodiesel emissions are part of the biogenic carbon cycle, these emissions are reported separately from Scopes 1, 2 and 3.

Emissions by Mine Activity

As shown in Figure 4, material hauling will generate 37% of the total mine emissions over of the life of the mine. Emissions generated from smelting account for more emissions than drilling, blasting, and loading combined. Mine operations support and maintenance, although not directly involved in material extraction or processing, account for 8% of the total emissions.

Figure 4: Average Annual Emissions by Activity



Reducing Emissions by Design

The Shakespeare project has been designed with the intention of minimizing GHG emissions.

All diesel consumed onsite will have a 50% biodiesel content (B50). Using biodiesel reduces lifecycle emissions because the carbon dioxide released when the fuel is combusted is offset by the carbon dioxide absorbed from growing the feedstocks used to produce the fuel. For this reason, emissions from biodiesel are reported separately from emissions from fossil sources, and do not need to be offset should Magna choose to remain carbon neutral.

Scope 2 emissions have been reported using the location-based Ontario grid emissions factor. Shakespeare's emissions profile benefits from its location in Ontario, which has a relatively clean electricity grid. Due to its reliance on nuclear and hydro power, the average emission intensity of each kWh consumed in Ontario is 0.029 $kgCO_2e/kWh$[4], one of the lowest of all provinces in Canada and twenty-seven times less GHG intensive than other major nickel-producing regions like Indonesia, at 0.769 $kgCO_2e/kWh$[5].

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[4] Canada's National Inventory Report (Part 3) 1990-2018, Table A13-7

[5] International Energy Association Emissions Factors 2021

Moving forward, Magna intends to finalize an agreement with HydroOne to provide a power line directly from a nearby dam to the Shakespeare site. When this agreement is in place, scope 2 emissions will be reduced to zero.

Further Emissions Reduction Opportunities

Magna is continuing to explore further opportunities for emissions reductions. Several opportunities have been outlined in Tables 2, 3 and 4 and Figure 5 based on the GHG reduction potential and the feasibility of their implementation.

If all reduction opportunities were implemented, Magna could further reduce their GHG emissions profile by 71.89%. If only high and medium feasibility initiatives were undertaken, emissions could be reduced by 34.71%.

While common in the mining industry, several opportunities that were not explored include on-site renewable power generation (due to Shakespeare's proximity to clean grid power), and mineral carbonation in mine tailings (as Shakespeare is not a serpentine rock deposit).

Table 2. Reduction Opportunities with High Feasibility

Opportunity	Impact	Absolute Reduction	% Reduction	Feasibility Rationale
Hybridization of Haul Trucks	~9% reduction in fuel consumption	5,986	3.3%	Targets the highest fuel consumers with available technology
Hybridization of Loading/Blasting Wheel Loaders	~35% reduction in fuel consumption	2,913	1.6%	Targets heavy equipment with available solutions
Electric Pickup Trucks	No diesel use	3,972	2.2%	Electric Vehicle infrastructure is proven technology
Electric Shuttle Bus	No diesel use	104	0.1%	Electric Vehicle infrastructure is proven technology
	Total	**12,975.56**	**7.3%**	

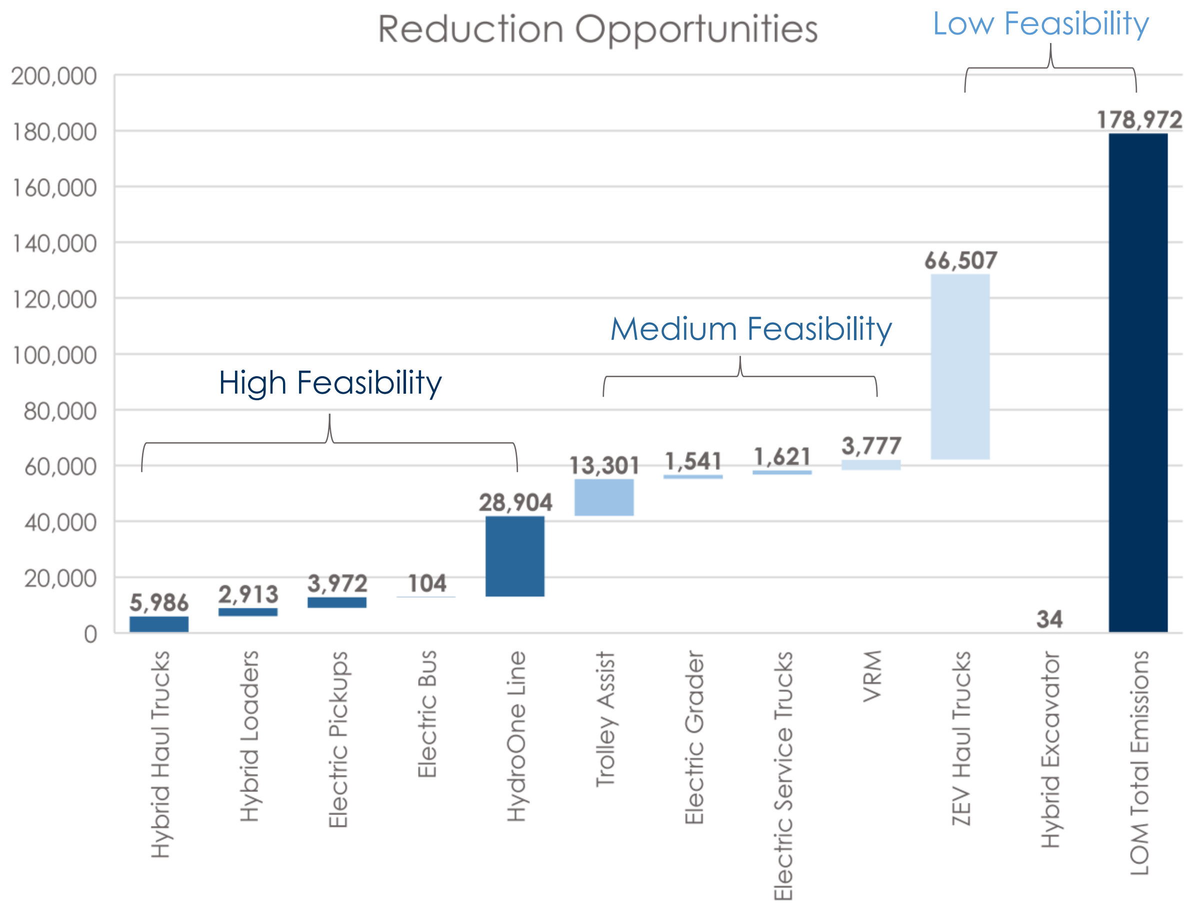
Table 3. Reduction Opportunities with Medium Feasibility

Opportunity	Impact	Absolute Reduction	% Reduction	Feasibility Rationale
Haul Truck Trolley Assist	~20% reduction in fuel consumption	13,301	7.4%	Significant reductions but requires extensive infrastructure
Electric Grader Conversion	no diesel use	1,541	0.9%	moderate reduction but requires costly conversion
Electric Service Trucks	no diesel use	1,621	0.9%	moderate reduction but relies on larger electric vehicle availability
Vertical Roller Mills (VRM)	15-30% reduction in energy consumption	3,777	2.1%	Would reduce electricity consumption by ~100,000 MWh over LOM
	Total	**20,241**	**11.3%**	

Table 4. Reduction Opportunities with Low Feasibility

Opportunity	Impact	Absolute Reduction	% Reduction	Feasibility Reason
Battery Electric or Hydrogen Haul Trucks	No diesel use	66,507	37.2%	Emerging Technology that is unlikely to be available during LOM
Hybrid Maintenance Excavator	~20% reduction in diesel consumption	34	0.0%	Costly equipment for minor reduction
	Total	**66,540**	**37.2%**	

Figure 5: Emissions Reduction Opportunities by Feasibility



Maintaining Carbon Neutrality

Magna is interested in maintaining carbon neutrality once the mine is operational by purchasing verified carbon credits from the voluntary market to offset emissions from mine activities.

If Magna were to offset emissions without pursuing any additional reduction opportunities (including finalizing the power purchase agreement with HydroOne), the LOM cost to maintain carbon neutrality would total $3,142,130, or $349,126 per year. If Magna successfully achieves all emissions reductions opportunities with high feasibility, LOM carbon neutrality costs would decrease to $2,095,133, or $232,793 per year. If they were to achieve all emissions reductions opportunities with medium and high feasibility, LOM carbon neutrality costs would total $1,589,110, or $176,568 per year. All carbon neutrality costs were calculated assuming offsets are available in the voluntary market for an average of $25 per tonne of carbon equivalent.