Whitepaper

An examination of how EcoHoist compares to conventional Skip Hoist systems, and how it can improve productivity and safety.

White Paper

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EcoHoist, a new energy-efficient centralised hoisting alternative

The future of underground mining is heading into greater depths. Something unavoidable to achieve the high resource demands from the green energy revolution. As miners venture deeper to extract the minerals and metals essential for a carbon-neutral economy, they are also confronted with the imperative to reduce emissions within their own operations.

In this white paper, we delve into the emerging trends, obstacles, and prospects associated with underground mining as it strives towards achieving net-zero emissions. We also explore the comparison with an existing sustainable solution, hoisting with an new innovative concept, EcoHoist. This whitepaper serves as a testament to how EcoHoist technology can maximise annual underground mining rates, prolong a mine's operational life, reduce operating expenditures, enhance safety measures, and, most importantly, contribute to emissions reduction.

Why centralised hoisting?

As a greener future grows on our horizon the demand for total minerals to achieve the targets set grows. Total demand is expected to quadruple by 2040, predicted the International Energy Agency (IEA), to meet sustainable development scenarios around the world. (IEA, 2021) As deposits deplete on the surface we will need to be going deeper to go greener. (ABB, 2023)

"We will need to be going deeper to go greener."- ABB, 2023

For example the amount of copper required for an electric vehicle is double that of a conventional one, with battery electric vehicles requiring upwards of 80 kilograms.(Copper Development Association Inc, 2021) A study examining over 55 porphyry copper deposits found the median depth of the deposits to be over 1 km deep, and porphyry copper-molybdenum deposits deeper, averaging 3.6 km. (Stinger, D. 1992) To meet rising demand and address the existing mineral supply crisis, underground miners will need the technology to support operations at these depths. (Ghorbani et al. 2023) This poses safety and operational challenges, particularly in adopting cleaner, sustainable methods for ore extraction.

Load and Haul is one of the primary material handling methods used in the mining industry. However for these operations to become carbon neutral, they will need to change from the traditional diesel fleets. Generally, load and haul activities can account for between 25-60% of overall emissions at an active operation. (Unearthed, 2023)

Electrification of these large fleets are starting to become adopted by miners as well as developed heavily through OEMs. However, deep operations will be limited by battery capacity, thus will be dependent on additional auxiliary infrastructure. (Spiller, B. 2023) The high usage rates will lead to rapid battery degradation, jeopardising the overall project's economics and embedded emissions. Additionally, with the current production rates of battery electric trucks, the entire industry would not be able to adopt this similar strategy.

Load and Haul will be required for the development of mines, however for production, a centralised service may provide a more sustainable solution. By detaching the vertical movement of the material from being dependent on the battery electric fleet, the overall operation can be further optimised.

Centralised hoisting must be considered when electrifying mines. At present, shaft hoisting is the industry's main form of centralised hoisting. Despite this, there are a range of alternatives which vary in cost and efficiency:

- Belt Conveyor
- Rail
- Shaft Hoist
- Trolley System
- Hydraulic Transport
- Belt Conveyors
- Vertical Conveyor

Shaft Hoisting Market

The Hoist for the mining market is primarily split into Friction Hoist, Drum Hoist and Blair Multi-rope Hoist. The Friction Hoist segment held the largest market share in 2021. Occompaning this the Coal Mine application occupied the biggest share from 2017 to 2022. (Market Reports World, 2022)

In 2022 the global hoisting for mining market reached $414 Million USD and is expected to grow at a CACG of 5.71% from 2023 to 2028 reaching $578 Million USD. In particular, the Asia Pacific region, with China and India as two major industrial centres, is expected to be the main contributors to growth of the hoisting sector. In 2021 the Asia Pacific region represented 38.89% share of the Hoist for Mining Markets. (Market Reports World, 2022)

“The global hoisting for mining market expected to reach USD 578 Million by 2028” - Market Reports *World*

As operations investigate how to expand to meet the demands of a carbon-neutral economy. Brownfield operations often centre their focus on the shaft and hoisting system available as they offer a sustainable, low emission and productive solution for deeper deposits. (ABB, 2023)

Key Companies for Shaft Hoisting Technology in Mining

- ABB
- Columbus Mckinnon Corporation
- Danfoss
- Deilmann-Haniel
- Dongqi Group
- FLSmith
- Frontier-Kemper
- Hepburn Engineering
- Inco Engineering
- Ingersoll Rand
- Kito
- Konecranes
- Luoyang CIC
- Olko - Maschinentechni
- Savona Equipment Ltd
- Sichuan Mining Machinery
- Siemag Tecberg
- Terex
- Uralmashplant
- Zitron

Comparison Overview

Skip Hoisting

Skip Hoisting systems are a well developed form of centralised hoisting for underground mines. The major components of hoist consist of a skip, which holds the material and is attached to the winder on the surface by wire ropes, the headframe and the hoist winder (winch and drum). The headframe supports the sheave wheel over which the wire rope is connected to the skip. As the drums in the surface hoist house wind the rope onto the drum, the skip is pulled to the surface, where it is dumped. (Kohler, J. et Al, 2015)
The skipping hoist system is cyclic, consisting of loading the skip, hoisting the skip, empting the skip and then lower back down the skip returning it to the beginning of its cycle. Cycles can take up to 1-5 minutes depending on the outfit of the hoist. There are multiple variations of skip hoists which can be selected depending on the purpose of the mine. (Sundström, T. 2014)

EcoHoist

EcoHoist is a new innovative method for optimising centralised hoisting which uses a continuous design for vertically handling the material. Based on the design from Economical Energy's patent pending VIPER technology, the EcoHoist has been designed to optimise the vertical transport of material. The system consists of a continuous chain system with bucket attachments that continuously hoist material to the surface in a conveyor like manner. The material is loaded at the base through a chute then into the bucket elevator where it reaches the surface where the material unloads in a bucket wheel like sprocket. The continuous nature of the Ecohoist maximises the utilisation of excavated area for the production equipment. (EcoHoist, 2023)

Utilisation

Capital investment required for the shaft excavation can be up to 20-30% of the overall project. (Appendix A) Hence decreasing a major cost component of a shaft project can bring major economic benefits for the operations and projects. As the Ecohoist system is designed to not have interaction amid the shaft there are no structural support or alignment rollers required. This minimises the space required, allowing enough space for only the bucket diameter to pass through, see Figure 1.

A shaft design has a rectangular skips which carries the material to the surface containing far less area within the shaft. If the purpose of the shaft is to be used for production and volume utilisation of the production shaft is defined as the amount of volume of production ore over total area of production area. Figure 1 displays the cross sectional area of a shaft and Ecohoist.

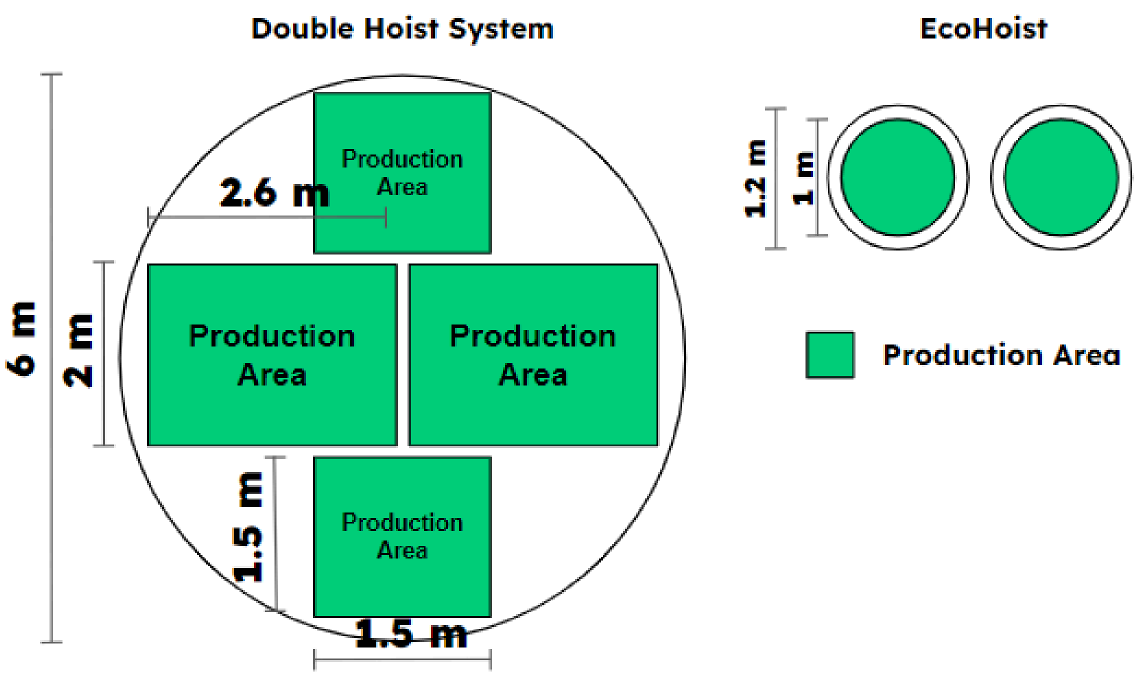

Figure 1: Visual comparison of a Double hoist system vs Ecohoist. Double hoist system based on McCarthy, P. (1999).

Calculations for the cross sectional area can be seen in Table 1.

Table 1: Calculation of cross sectional area.

	EcoHoist	Double Hoist System	
Production Area	0.8	16.4	m2
Total Area	1.1	28.3	m2
Cross Sectional Utilisation	69%	58%	

The utilisation area of a shaft system is clearly less that of the EcoHoist.

If utilised volume is defined as:

$$Utilised\ Volume\ =\ Volume\ of\ Production\ Material\ in\ Transport/Total\ Excavated\ Volume$$

The calculation for utilised volume has been calculated for the Double Hoist Shaft and Ecohoist as seen in Table 2 & 3 .

Table 2: Comparison of volume excavated.

	EcoHoist	Double Hoist System	
Production	5.5	5.5	Mtpa
Diameter	1.2	6.0	m
Depth	1,000	1,000	m
Shaft Volume	1,131	33,183	m3
Total Volume	2,262 (2 Shafts)	33,183	m3

By decreasing the required volume of material decreases capital investment but also decreases the emissions required for construction.

"Over 90% less material to be removed for EcoHoist" - EcoHoist

Table 3: Volume of Hoisting

	EcoHoist	Double Hoist System	
Production Rate	5.5	5.5	Mtpa
Mass of Material	85	90	t
Density	1.95	1.95	t/m3
Volume of Material	43.6	46.2	m3
Total Volume	2261.9 (2 Shafts)	33,183.07	m3
Shaft Utilisation	2.75%	0.163%	

“17X better Shaft Utilisation” - EcoHoist

Shaft Excavation Emissions

The emissions created when excavating the shaft can be proportional to the volume of material removed. In this example two scenarios were considered for required excavation of volume both an EcoHoist and Double Hoist Systems with similar output rates. As seen below the additional volume of material removed reduces by over 96.6% which reduces emission by over 30%. (Rodriguez, R., 2021) Further calculations can be seen in Appendix B

	EcoHoist	Double Hoist System	
Production	5.5	5.5	Mtpa
Diameter	1.2	6.5	m
Depth	1000	1000	m
Shaft Volume	1131.0	33,183.1	m3
Total Volume	2261.9 (2 Shafts)	33,183.1	m3
CO2 Emissions (RAISE BORE)	864,700	1,146,000	kg CO2
CO2 Emissions (Waste Disposal)	11,500	168,570	kg CO2
Total Emissions	876,200	1,314,570	kg CO2

"By decreasing the required diameter of the shaft, scope one construction emissions can be reduced by over 30%" - EcoHoist

Energy Usage

A mine hoist poses a significant strain on the power grid within a mining operation, primarily due to its frequent and abrupt changes in power consumption. (Johansson, B., 2010) The numerous rapid fluctuations experienced through each hoisting cycle result in substantial disturbances in the network, manifesting as voltage irregularities. Remote Mines often rely on local diesel generators or gas turbines for power generation. However, these sources are unable to adapt swiftly enough to meet the hoist's demanding power requirements. Consequently, this can lead to fluctuations in network voltage and/or frequency, which may be deemed unacceptable for the mine hoist and other connected equipment. Furthermore, the power generation must be sized to accommodate the peak power demand, necessitating a substantial allocation of spinning power. (Johansson, B., 2010) This translates to increased operational expenses and reduced efficiency. Additional capital expenditure invested into flywheels or BESS systems to rescue the peak power demand, power swing and power change of the hoisting system. The typical power demand can be seen as the red line on Figure 3 for a single cycle of a Double Hoist System.

EcoHoist continuous design provides a continuous power draw profile. The continuous nature omits the power drawbacks of a cyclic system and does not then require the additional supporting infrastructure reducing capital investment. With a continuous power system the peak power consumption is greatly reduced, further reducing the required capacity, and associated cost. See the green line in Figure 3 for the power demand of EcoHoist.

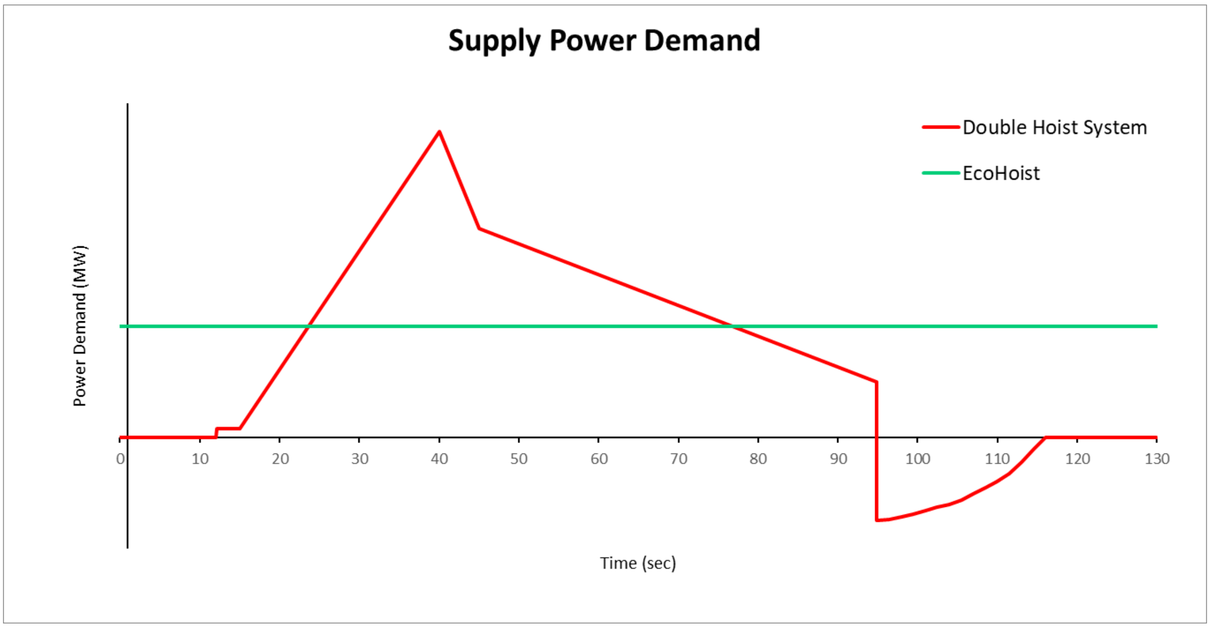

Figure 3: Double Hoist System and EcoHoist power demand comparison.

“Ecohoist continuous power draw profile reduces capital investment and increases efficiency.” - EcoHoist

Maintenance

As part of the Ecohoist design the shafts have been designed to facilitate the material handling mechanism hence no structural support or alignment rollers required. With the shaft being composed of a dead vertical shaft with a liner there will be no requirement for personnel access to the shaft. This eliminates the requirement of personnel to be entering confined spaces and inspections can be conducted via remote monitoring. Reducing the OPEX for general maintenance and inspection, whilst being safer.

"EcoHoist does not require personnel to enter the shaft." - EcoHoist

Installation

With 90% less material being removed with EcoHoist optimised design utilising narrower shafts. The installation time of the overall project decreases dramatically, as time spent excavating material is less. The narrow shaft design allows standard raise bore technology to be adopted providing a faster, more efficient method than Traditional Shaft Sink. BHP, Prominent Hill estimated their shaft to progress at a rate of 1.5m/day (Oz Minerals, 2021), whilst conventional raise boring is estimated at average rate of 5.6 m/day (Pilot and Reaming Included) (Shaterpor-Mamaghani, A., 2016). See Figure 4 for an example comparison of a traditional shaft sink and the installation of EcoHoist.

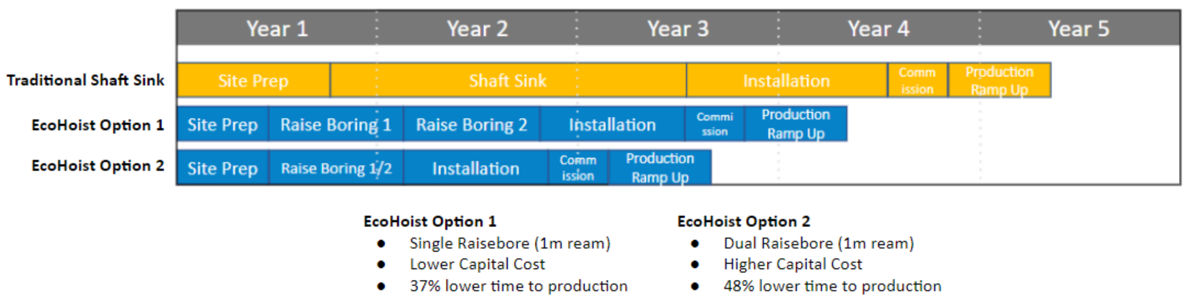

Figure 4: Example for time line comparison for traditional shaft sink vs Ecohoist.

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APPENDIX A

Cost of Shafts projects

A selection of recent shaft projects have been investigated to uncover the cost of the overall project and the cost of the shaft excavation. As seen in Table A the average percentage is around 20% of the overall cost.

Table A Cost breakdown of projects and shaft excavation cost. Data inputs from multiple sources. (Oz Minerals, 2021), (GR Engineering Services, 2021), (Canadian Mining Journal, 2022), (Mining Review Africa, 2020), (Queen's University, 2014)

Project	Shaft Excavation	Overall Project	
Prominent Hill - BHP 2023	115	597	19.3%
Newmont - Tamini 2023	68	395	17.2%
Kirkland Lake Gold - Macassa 4# Shaft Project 2022	~72	320	22.5%
Caledonia - Blanket Gold 2020	~10.8	60	18%

APPENDIX B

Emissions Calculations

For calculating the emission of alternative shaft diameters, the energy requirements from a range of raisebores was considered. The generators for the raise bores and their fuel consumption was considered as the primary emissions source. See Table B for the inputs for the emission calculations. It should be noted that the following assumptions were made.

- Max load is 750kN Diesel Generator (ADE, 2023))
- CO2 Emissions of Diesel os 2.63 kg CO2/L (NTC, 2019)
- Weightings of Raise Bore is proportional to the diameter of the ream (6m = 100%)

Table B: shows the inputs for the calculation of the overall emissions for each of the raise bore diameters.

Raise Bore Emmission Diesel		
Depth	1000	m
Pilot	111	days
Ream	100	days
Utilisation	90.00%	
Pilot Hrs	2400	hr
Ream Hrs	2160	hr
Max Ltrs/Hr	149.5	l/hr
Baseload	10%	
Dia. Pilot	15.82%	
Ream (1.2m)	30.00%	
Ream (6)	100%	
Ltrs/Hr Pilot Adj	23.64591667	l/hr
Ltrs/Hr Ream (1.2) Adj	44.85	l/hr
Ream Ltrs	149.5	l/hr
Pilot Ltrs	56,750	L
Ream (1.2) Ltrs	107,640	L
Ream (6) Ltrs	322,920	L
Volume Removed Pilot	96	m3
Volume Removed Ream (1.2m	1131	m3
Volume Removed Ream (6m)	28274	m3
CO2 Emmison (Disel)	2.63	kg CO2/L
CO2 Emmison (LPG)	2.31	kg CO2/L
Pilot CO2	149253.026	kg CO2
Ream CO2	283093.2	kg CO2
Ream CO2	849279.6	kg CO2
Pilot CO2/m3	149.253	CO2/m
Ream (1.2) CO2/m3	250.3	CO2/m3
Ream (6) CO2/m3	30.0	CO2/m3