



OPEN

Enhancing sustainability in mining by reducing hauling energy consumption through optimization of distance and slope with semi-mobile in-pit crushers and conveyors

Rouzbeh Nikbin¹, Raheb Bagherpour^{1✉}, Ehsan Purhamadani¹ & Arash Taherinia²

Increasing energy efficiency in climate change mitigation has become essential due to continuous population growth and rising energy consumption. Energy-intensive industries, such as mining, have areas for improving energy consumption. Haulage systems have often been considered for optimization in mining operations. Therefore, this research aims to evaluate Semi-Mobile In-Pit Crushers and Conveyors (SMIPCC) to optimize loading and haulage systems and reduce energy consumption. For this purpose, two loading and hauling scenarios were considered: the first was based on discontinuous loading and haulage, and the second was based on semi-continuous loading and haulage using SMIPCC. First, two potential locations are assessed and investigated based on the ore deposit's center of gravity. Also, eight potential sites for placing four crushers related to waste crushing are obtained. Next, the slope and distance within these potential locations are evaluated and compared. After this, the optimal location is selected based on minimizing slope and distance. The obtained slope and distance values for each crusher are then compared with the current values from the first scenario. Finally, XGBoost and Random Forest models were used to predict energy consumption in the initial locations. After comparing the models based on R^2 and MAPE criteria, the Random Forest model was the most accurate for predicting diesel fuel consumption with an R^2 of 0.88 and a MAPE of 5.7425, respectively. The results demonstrated that SMIPCC systems reduced truck energy consumption by 24%. In addition, a significant reduction in CO₂ emissions was observed, reaching approximately 25%. Such improvements indicate the reliability of SMIPCC systems in promoting reduced energy consumption and sustainable mining operations.

Keywords Energy efficiency, Climate change mitigation, Sustainable mining, Semi-Mobile-in-pit crusher, Conveyor, CO₂ emissions

With the increasing world population, the growth and development of technology are obvious to meet human needs, while the world economy has also experienced significant growth in recent years¹. Economic growth has a direct relationship with the growth rate of energy consumption². The developed countries, compared to developing countries, had allocated the highest amount of energy consumption in the world³. The World Energy Institute and British Petroleum Company (BP) report showed that energy consumption in different forms increased from 5653 TWh (1880) to 179,819 TWh (2023) (Fig. 1). Based on the population growth forecast, the population will rise by 80% in the world by 2050 compared to 2020⁴. Also, Eden (1993) estimated that the energy consumption growth rate will increase by 50% until 2050⁵.

Also, the United States Energy Information Administration findings show that energy consumption per person in the countries with the highest energy consumption has increased from 220,707 kWh (1965) to 283,462 kWh (2023) per person (Fig. 2)⁶.

¹Department of Mining Engineering, Isfahan University of Technology, Isfahan 8415683111, Iran. ²Sarcheshmeh Copper Complex, National Iranian Copper Industries Co., Kerman, Iran. ✉email: bagherpour@iut.ac.ir