Addressing energy efficiency in quarries – First stage in the development of a holistic approach

F. Sanchez and P. Hartlieb

Montanuniversität Leoben, Austria

INTRODUCTION

Large amounts of energy are consumed across the different unit processes of the mining value chain, e.g. loading and hauling, comminution, and milling. Accordingly, energy efficiency has long been an important concern in the industry. Energy management actions have been researched and developed transversally, initially driven by the need to reduce operational costs, but increasingly also aiming to improve the sustainability of operations. Energy consumption relates directly to greenhouse gas emissions, thus improving its efficiency or moving to cleaner energy sources is critical in a climate change context and under the scrutiny of communities and general stakeholders[1].

Among the different mining industries, quarries represent the largest portion of global mineral production[2], significantly impacting the environmental footprint of the entire sector. Hence, the importance of working towards more sustainable quarrying operations.

The research project in which this paper is framed aims to introduce further digitisation and automation in the quarrying sector in Europe, to enhance economic, environmental, and safety indicators, towards sustainable and ethical mining practices. Subsequently, this specific study focuses on addressing energy efficiency. As a first step, this document presents an overview of how this topic can be tackled comprehensively in quarries. For this purpose, energy consumption at a range of small to medium-scale quarries is assessed. The main energy-related challenges are analysed, considering the distinctive nature of each site, geology, processes, and products. Likewise, potential rooms for improvement for different quarry scenarios are identified.

METHODOLOGY

Five quarrying companies provide the pilot sites to test and validate the technologies and strategies developed in the project. These operations are located in five different countries of Europe, and exploit diverse products, granting a wide perspective on the quarrying sector.

The analysis of energy efficiency in the project follows two complementary approaches. First, a general assessment is conducted, considering the general layout of each site, machinery, processes, and related practices. The goal is to achieve a deeper understanding of the energy requirements of quarries, main consuming processes, and the most relevant challenges.

[1] Igogo, T., Awuah-Offei, K., Newman, A., Lowder, T., & Engel-Cox, J. (2021). Integrating renewable energy into mining operations: Opportunities, challenges, and enabling approaches. *Applied Energy*, *300*, 117375.
[2] Oberle, B., Bringezu, S., Hatfield-Dodds, S., Hellweg, S., Schandl, H., & Clement, J. (2019). *Global resources outlook: 2019*. International Resource Panel, United Nations Envio.

The second approach consists of applying data analysis techniques, e.g. statistical methods, and machine learning, to model the relationship between operational parameters and overall energy consumption. As a result, global energy efficiency strategies can be developed, and environmental performance enhanced. The data will be collected, stored, and accessed through a series of sensors, cameras, and digital platforms, implemented as part of the project's efforts to digitise and automate quarries. In this paper, the primary findings of the general assessment (first approach) are discussed.

GENERAL ASSESSMENT

Table 1 summarises the main features of the sites, indicating the relevant energy-consuming equipment in each case. As it can be seen, quarries in this project, as in general, employ different technologies and configurations according to their specific characteristics, i.e. geology, size, location, overburden, and others. Additionally, Figure 1 shows the average annual electricity and fuel/diesel consumption at each site, along with the specific consumption per ton of material produced.

Generally, material handling and comminution are the most energy-intensive processes, but at the same time the ones with the most potential for improvement[3]. Correspondingly, these areas have been identified as the ones consuming most of the energy in the analysed operations.

Preliminary, fleet optimisation, i.e. the optimal amount of loaders and trucks, and reduction of idle times, have been proposed as strategies to explore in sites 1, 2, and 3. On the other hand, improvements in the operation of conveyor belts, i.e. better integration between different sections for coordinated functioning will be examined in sites 4 and 5. In parallel, analysis of other sources of energy, e.g. renewables, or switching from fuel to electric-powered equipment is also part of the study.

FINAL COMMENTS AND NEXT STEPS

This first approach allows exploration of the key leveraging points for improvement, but also to design the proper strategies for data collection and analysis in the second stage of the project. Likewise, set the basis for proposing suitable prediction and optimisation models to achieve energy efficiency goals and environmental impact reduction.

As mentioned, energy efficiency is crucial from the sustainability point of view, but also from the cost perspective. Currently, energy represents between 30% and 60% of the operational cost of the investigated sites. Moreover, if no actions are taken, this could increase in the upcoming period, as energy prices continue to rise. However, if the energy reduction goals in the project are met (5%-20%, depending on the source and site), annual savings between €600,000 and €1,000,000 can be expected (considering current energy prices).

[3] Awuah-Offei, K. (2016). Energy efficiency in mining: a review with emphasis on the role of operators in loading and hauling operations. *Journal of Cleaner Production*, *117*, 89-97.

Table 1. Description of pilot sites.

	Site #	1	2	3	4	5
General	Extraction method	Drill & blasting	Drill & blasting	Drill & blasting	Dredging	None
	Main product	Limestone	Andesite	Limestone	Sand & gravel	Recycled material
	Product[kt/y]	1,300	1,200	1,200	400	41
Machinery consuming fuel and diesel	Drills	✓	✓	✓		
	Excavator		✓	✓		
	Mobile crusher		✓			
	Wheel loader	✓	✓	✓		✓
	Trucks	✓	✓	✓		
Machinery consuming electricity	Dredge				✓	
	Conv. belts	✓	✓	✓	✓	✓
	Screeners	✓	✓	✓	✓	✓
	Crushers	✓	✓	✓	✓	✓

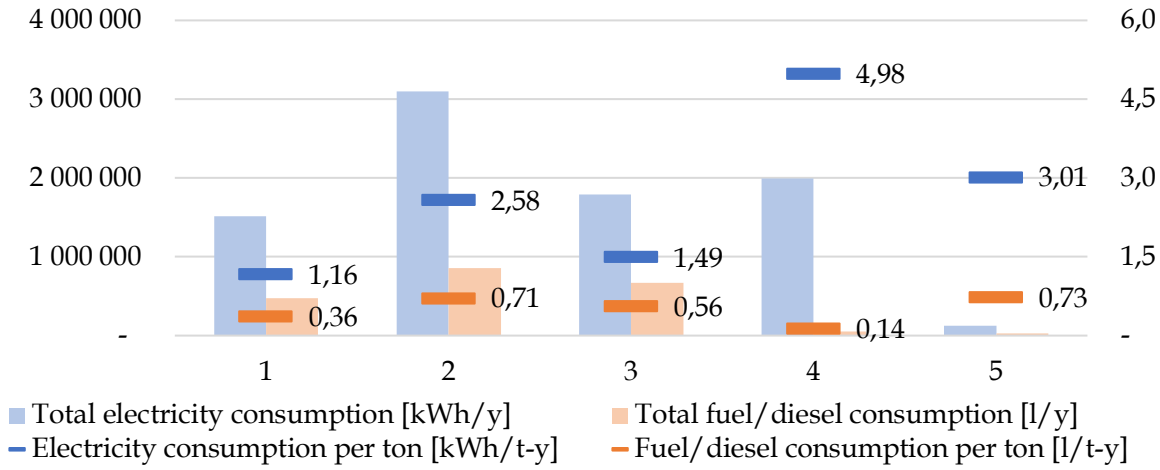

Figure 1. Electricity and fuel/diesel consumption of sites.

ACKNOWLEDGEMENTS

This work has received funding from the European Union's Horizon 2020 research and innovation program, under grant agreement No 101003750.

Felipe Sanchez

Researcher and PhD Student
Chair of Mining Engineering and Mineral Economics, Montanuniversität Leoben, Austria

Felipe Sanchez is an Industrial and Mining Engineer from Chile. For most of his professional career, he has worked for the Chilean Copper Commission in the technical and economic evaluation of medium- and large-scale mining projects, and also in the research and analysis of mineral policy. He has also been appointed as a lecturer for courses on Evaluation of Mining Projects and conducted consulting activities for mining investors. Currently, he works as a researcher at the University of Leoben in Austria, while pursuing PhD studies in Mining Engineering and Sustainability.